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- **KIM, Minki**
Hwaseong-Si Gyeonggi-do 18484 (KR)
- **KIM, Byeong-Beom**
Asan-Si Chungcheongnam-do 31470 (KR)
- **KIM, Seunggho**
Asan-Si Gyeonggi-do 31466 (KR)
- **KIM, Yuri**
Guri-Si Gyeonggi-do 11921 (KR)
- **YEUM, Jonghoon**
Seoul 07445 (KR)

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(71) Applicant: **Samsung Display Co., Ltd.**
Gyeonggi-do 17113 (KR)

(74) Representative: **Dr. Weitzel & Partner**
Patent- und Rechtsanwälte mbB
Friedenstrasse 10
89522 Heidenheim (DE)

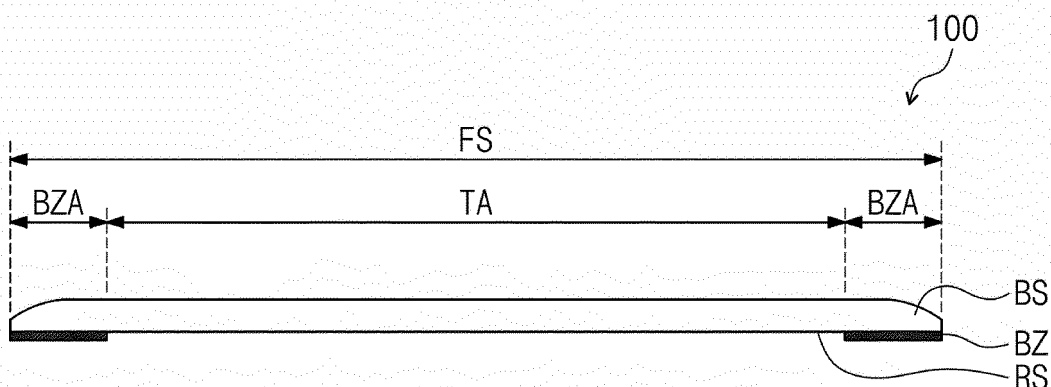
(72) Inventors:
• **LEE, Hoikwan**
Suwon-Si Gyeonggi-do 16662 (KR)

(54) **WINDOW AND MANUFACTURING METHOD THEREFOR**

(57) A window according to the present invention includes a base substrate including a front surface and a rear surface and a bezel layer disposed on the rear sur-

face of the base substrate. The front surface of the base substrate has a roughness in a range of 0.2 nm to 3 nm.

FIG. 3A



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Description

TECHNICAL FIELD

[0001] The present invention relates to a window and a method of manufacturing the same, and more particularly, to a window including glass and a method of manufacturing the same.

BACKGROUND ART

[0002] Electronic devices include windows, housing units, and electronic elements. The electronic elements may include various elements such as display elements, touch elements, or detection elements which are activated in response to electrical signals.

[0003] The windows protect the electronic elements and provide users with active areas. Accordingly, the users provide inputs to the electronic elements through the windows or receive information generated in the electronic elements. Also, the electronic elements may be stably protected from external impact by the windows.

[0004] Recently, in response to the trend toward slimmer electronic devices, the windows have also been required to be lightweight and thin, and in order to compensate for resultant structural vulnerability, a variety of methods for strengthening the windows have been researched.

DISCLOSURE OF THE INVENTION

TECHNICAL PROBLEM

[0005] The purpose of the present invention is to provide a chemically strengthened window and a method of manufacturing the same.

TECHNICAL SOLUTION

[0006] A window according to an embodiment of the present invention includes: a base substrate including a front surface and a rear surface; and a bezel layer disposed on the rear surface of the base substrate, wherein the front surface has a roughness in a range of 0.2 nm to 3 nm.

[0007] The base substrate may include glass.

[0008] The base substrate may include a lithium oxide (Li_2O).

[0009] The base substrate may further include a phosphorus oxide (P_2O_5).

[0010] Compressive stress may be applied within a range from the front surface to a predetermined depth in a thickness direction of the base substrate.

[0011] A predetermined bending axis may be defined, which extends in a direction crossing a thickness direction of the base substrate, and at least a portion of the base substrate may be bending about the bending axis.

[0012] A method of manufacturing a window according

to an embodiment of the present invention includes: a step of providing an initial window which includes glass and includes a lithium oxide; and a washing step of washing the initial window, wherein the washing step includes: an acid washing step of providing the initial window into an acidic environment; and a base washing step of providing the initial window, which has been subjected to the acid washing step, into a basic environment.

[0013] The acidic environment may have a pH of 2 or lower.

[0014] The acidic environment may include an acidic solution including at least one of nitric acid (HNO_3), sulfuric acid (H_2SO_4), or hydrochloric acid (HCl).

[0015] The acid washing step may be performed for about 20 minutes at a temperature of 60°C to 65°C.

[0016] The basic environment may have a pH of 13 or higher.

[0017] The basic environment may include a basic solution including at least one of sodium hydroxide (NaOH) or potassium hydroxide (KOH).

[0018] The window, which has been subjected to the acid washing step, may include: a first layer which includes an alkali metal and silicon that has a predetermined content ratio with respect to the alkali metal; and a second layer which is formed on a surface of the first layer and has a higher silicon content ratio than the first layer.

[0019] The second layer may be formed at a portion of the initial window, from which the alkali metal is eluted out during the acid washing step.

[0020] A thickness of the second layer may be 200 nm to 500 nm.

[0021] During the base washing step may form a window by removing the second layer from the first layer.

[0022] A surface roughness of the window may be less than or equal to a surface roughness of the initial window.

[0023] A surface roughness of the window, which has been subjected to the acid washing step, may be greater than or equal to a surface roughness of the initial window.

[0024] The step of providing the initial window may include the steps of: providing a glass substrate; and strengthening the glass substrate, wherein the step of strengthening includes an ion exchange treatment, and the step of providing the initial window is to provide strengthened glass substrate.

[0025] The step of providing the initial window may further include the steps of: providing a mother substrate; forming a plurality of unit substrates by cutting the mother substrate; and chamfering side surfaces of the unit substrates, wherein the glass substrate is one of the unit substrates which have been subjected to the step of chamfering.

[0026] A method of manufacturing a window according to an embodiment of the present invention includes the steps of: chemically strengthening a glass substrate so that a first initial substrate is formed; washing the first initial substrate with an acidic solution by providing the first initial substrate into an acidic solution so that a sec-

ond initial substrate is formed; and washing the second initial substrate with a basic solution by providing the second initial substrate into the basic solution so that a window is formed, wherein a roughness of the window ranges from 0.2 nm to 3 nm.

[0027] The glass substrate may include a lithium oxide.

[0028] The step of chemically strengthening may not include potassium carbonate (K_2CO_3), sodium carbonate (Na_2CO_3), potassium bicarbonate ($KHCO_3$), sodium bicarbonate ($NaHCO_3$), potassium phosphate (K_3PO_4), sodium phosphate (Na_3PO_4), potassium sulfate (K_2SO_4), sodium sulfate (Na_2SO_4), and potassium hydroxide (KOH).

[0029] The second initial substrate may be formed by eluting out an alkali metal from the first initial substrate.

[0030] The second initial substrate may include a first layer, which has substantially the same content ratio of silicon to the alkali metal as the first initial substrate, and a second layer, which is formed on a surface of the first layer and has a higher content ratio of the silicon to the alkali metal than the first layer.

[0031] The second layer may have relatively higher pores than the first layer.

[0032] The window may be formed by removing the second layer from the second initial substrate.

ADVANTAGEOUS EFFECTS

[0033] According to the present invention, the window having the improved strength may be provided. Also, according to the present invention, the method of manufacturing the window may be provided, which provides the strengthened window through the simplified processes.

BRIEF DESCRIPTION OF THE DRAWINGS

[0034]

FIG. 1 is a perspective view of an electronic device according to an embodiment of the present invention.

FIG. 2a is an exploded perspective view of the electronic device illustrated in FIG. 1.

FIG. 2b is an equivalent circuit diagram for some components of the electronic device.

FIG. 3a is a cross-sectional view of a window according to an embodiment of the present invention.

FIG. 3b is a microscopic image of a portion of the window illustrated in FIG. 3a.

FIG. 4 is a flowchart schematically illustrating a method of manufacturing a window according to an embodiment of the present invention.

FIGS. 5a to 5g are cross-sectional views schematically illustrating a method of manufacturing a window according to an embodiment of the present invention.

FIG. 6 is a graph illustrating a change in thickness of an intermediate layer over time during some steps

in a method of manufacturing a window.

FIG. 7a is a microscopic image of a surface of an intermediate window.

FIG. 7b is a microscopic image of a surface of a window according to an embodiment of the present invention.

FIG. 8 is a graph showing the strength of the window according to an embodiment of the present invention.

FIG. 9 is a flowchart illustrating a method of manufacturing a window according to an embodiment of the present invention.

FIGS. 10a to 10c are perspective views illustrating a method of manufacturing a window according to an embodiment of the present invention.

FIGS. 11a to 11c are perspective views illustrating a method of manufacturing a window according to an embodiment of the present invention.

FIG. 12 is a perspective view illustrating a window according to an embodiment of the present invention.

FIGS. 13a and 13b are perspective views illustrating windows according to an embodiment of the present invention.

MODE FOR CARRYING OUT THE INVENTION

[0035] In the specification, it will be understood that when an element (or a region, a layer, a portion, or the like) is referred to as being "on", "connected to" or "coupled to" another element, it can be directly disposed on/connected/ coupled to another element mentioned above, or intervening elements may be disposed therebetween.

[0036] Like numbers refer to like elements throughout. Also, in the drawings, the thicknesses, ratios, and dimensions of the elements are exaggerated for effective description of the technical contents.

[0037] The term "and/or" includes one or more combinations which can be defined by the associated elements.

[0038] Although the terms first, second, etc. may be used herein to describe various elements, these elements should not be limited by these terms. These terms are only used to distinguish one element from another element. For example, a first element may be referred to as a second element, and similarly, a second element may be referred to as a first element without departing from the scope of the present invention. The singular forms include the plural forms unless the context clearly indicates otherwise.

[0039] Also, terms such as "below", "lower", "above", and "upper" may be used to describe the relationships of the components illustrated in the drawings. These terms have a relative concept and are described on the basis of the directions indicated in the drawings.

[0040] Unless otherwise defined, all terms (including technical and scientific terms) used herein have the same

meaning as commonly understood by one of ordinary skill in the art to which the present invention belongs. Also, terms such as those defined in commonly used dictionaries should be interpreted as having a meaning that is consistent with their meaning in the context of the relevant art, and will not be interpreted in an idealized or overly formal sense unless expressly so defined herein.

[0041] It will be understood that the term "includes" or "comprises", when used in this specification, specifies the presence of stated features, integers, steps, operations, elements, components, or a combination thereof, but does not preclude the presence or addition of one or more other features, integers, steps, operations, elements, components, or combinations thereof.

[0042] Hereinafter, embodiments of the present invention will be described with reference to the accompanying drawings.

[0043] FIG. 1 is a perspective view of an electronic device according to an embodiment of the present invention. FIG. 2a is an exploded perspective view of the electronic device illustrated in FIG. 1. FIG. 2b is an equivalent circuit diagram for some components of the electronic device. Hereinafter, the present invention will be described with reference to FIGS. 1 to 2b.

[0044] The electronic device EA may be a device which is activated in response to an electrical signal. The electronic device EA may include various embodiments. For example, the electronic device EA may include a tablet, a laptop, a computer, a smart television, or the like. In the embodiment, the electronic device EA is illustratively shown as a smart phone.

[0045] The electronic device EA may display an image IM, in a third direction D3, on a display surface FS parallel to each of a first direction D1 and a second direction D2. A display surface FS, on which the image IM is displayed, may correspond to a front surface of the display device EA and may also correspond to a front surface FS of a window member WM. Hereinafter, the same reference symbol is used to denote the display surface and front surface of the electronic device EA and the front surface of the window member WM. The image IM may include static images as well as dynamic images. In FIG. 1, an internet search window is illustrated as one example of the image IM.

[0046] In the embodiment, a front surface (or a front surface) and a rear surface (or a bottom surface) for each member are defined with respect to the direction in which the image IM is displayed. The front and rear surfaces are opposed to each other in the third direction D3, and the normal direction of each of the front and rear surfaces may be parallel to the third direction D3. The distance between the front and rear surfaces in the third direction D3 may correspond to the thickness of a display panel DP in the third direction D3. Here, directions, which are indicated as the first to third directions D1, D2, and D3, may have a relative concept and thus may be changed to other directions. Hereinafter, the first to third directions refer to the same reference symbols as the directions

indicated by the first to third directions D1, D2, and D3, respectively.

[0047] The electronic device EA includes a window 100, an electronic panel 200, and a housing member 300. In the embodiment, the window 100 and the housing member 300 are coupled to each other to define an exterior of the electronic device EA.

[0048] As described above, the front surface FS of the window 100 defines the front surface of the electronic device EA. A transmissive area TA may be an optically transparent area. For example, the transmissive area TA may be an area having a visible light transmittance of about 90% or higher.

[0049] A bezel area BZA may be an area having a relatively lower light transmittance than the transmissive area TA. The bezel area BZA defines a shape of the transmissive area TA. The bezel area BZA is adjacent to the transmissive area TA and may surround the transmissive area TA.

[0050] The bezel area BZA may have a predetermined color. The bezel area BZA may cover a peripheral area NAA of the electronic panel 200 to prevent the peripheral area NAA from being viewed from the outside. However, this is merely illustrated as an example, and the bezel area BZA may be omitted in the window member 100 according to an embodiment of the present invention.

[0051] The window 100 may include an insulating material. For example, the window 100 may include glass. The window 100 may provide the transmissive area TA by using the light transmittance of the glass and stably protect the electronic panel 200 from external impact by using the strength of the glass. This will be described later in detail.

[0052] The electronic panel 200 may be activated in response to an electrical signal. In the embodiment, the electronic panel 200 is activated to display the image IM through a front surface IS. The image IM may be provided to a user through the transmissive area TA, and the user may receive information through the image IM. However, this is merely illustrated as an example, and the electronic panel 200 may be activated to detect an external input applied to the front surface. The external input may include a user's touch, contact or approach of immaterial matters, pressure, light, or heat, but the embodiment is not limited to any one embodiment.

[0053] The front surface IS of the electronic panel 200 may include an active area AA and a peripheral area NAA. The active area AA may be an area on which the image IM is displayed. The transmissive area TA overlaps the entire surface or at least a portion of the active area AA.

[0054] The peripheral area NAA may be an area covered by the bezel area BZA. The peripheral area NAA is adjacent to the active area AA. The peripheral area NAA may surround the active area AA. A driving circuit, a driving line, or the like for driving the active area AA may be disposed in the peripheral area NAA.

[0055] The active area 200 may include a plurality of pixels PX. The pixels PX display light in response to an

electrical signal. The light displayed by the pixels PX makes the image IM. In FIG. 2b, an equivalent circuit diagram of one pixel PX is schematically illustrated for ease of description. Hereinafter, the pixel PX will now be described with reference to FIG. 2b.

[0056] The pixel PX may be connected to a plurality of signal lines. In the embodiment, the pixel PX is illustrated as being connected to a gate line GL, a data line DL, and a power line PL. However, this is merely illustrated as an example. The pixel PX according to an embodiment of the present invention may be connected to additional signal lines, which are not illustrated, and receive various electrical signals, but the embodiment is not limited to any one embodiment.

[0057] The pixel PX includes a first transistor TR1, a second transistor TR2, a capacitor CP, and a light emitting element ED. In the embodiment, the display element ED is illustratively shown as an organic light emitting element. However, the configuration of the pixel PX is not limited thereto and may be variously modified and implemented.

[0058] A first thin film transistor TR1 may be a switching element for controlling an on-off state of the pixel PX. In response to a gate signal transmitted through the gate line GL, the first thin film transistor TR1 may transmit or block data signal transmitted through the data line DL.

[0059] The capacitor CP may be connected to the first thin film transistor TR1 and the power line PL. The capacitor CP charges a quantity of electric charge corresponding to a difference between the data signal transmitted from the first thin film transistor TR1 and a first power signal applied to the power line PL.

[0060] A second thin film transistor TR2 is connected to the first thin film transistor TR1, the capacitor CP, and the display element ED. Corresponding to the quantity of electric charge stored in the capacitor CP, the second thin film transistor TR2 controls driving current that flows through the display element ED. Depending on the quantity of electric charge charged in the capacitor CP, a turn-on time of the second thin film transistor TR2 may be determined. The second thin film transistor TR2 provides the first power signal, which is transmitted through the power line PL during the turn-on time, to the display element ED.

[0061] The display element ED may generate light or control a quantity of light depending on the electrical signal. For example, the display element ED may include an organic light emitting element, a quantum dot light emitting element, a liquid crystal capacitor, an electrophoretic device, or an electrowetting device.

[0062] The display element ED is connected to a power terminal VSS and receives a power signal (hereinafter, referred to as a second power signal) which is different from the first power signal provided from the power line PL. Driving current, which corresponds to a difference between the second power signal and the electrical signal provided from the second thin film transistor TR2, flows through the display element ED, and the display

element ED may generate light corresponding to the driving current. Here, this is merely illustrated as an example. The pixel PX may include electronic elements having various configurations and arrangements, but the embodiment is not limited to any one embodiment.

[0063] Referring to FIG. 2a again, the housing member 300 is disposed below the electronic panel 200. The housing member 300 is coupled to the window 100 to define the exterior of the electronic device EA. The housing member 300 may include a material having relatively high rigidity. For example, the housing member 300 may include a plurality of frames and/or plates made of glass, plastic, and metal. The housing member 300 provides a predetermined accommodation space. The electronic panel 200 may be accommodated in the accommodation space and thus protected from the external impact.

[0064] FIG. 3a is a cross-sectional view of a window according to an embodiment of the present invention. FIG. 3b is a microscopic image of a portion of the window illustrated in FIG. 3a. Hereinafter, the present invention will be described with reference to FIGS. 3a and 3b.

[0065] As illustrated in FIG. 3a, a window 100 may include a base substrate BS and a bezel layer BZ. The base substrate BS may be optically transparent. In the embodiment, the base substrate BS may include glass.

[0066] A front surface FS of the base substrate BS is exposed to the outside of an electronic device EA, and defines a front surface FS of the window 100 and a front surface FS of the electronic device EA. A rear surface RS of the base substrate BS is opposed to the front surface FS in a third direction DR3.

[0067] The bezel layer BZ is disposed on the rear surface RS of the base substrate BS and defines a bezel area BZA. The bezel layer BZ may have light transmittance relatively lower than that of the base substrate BS. For example, the bezel layer BZ may have a predetermined color. Accordingly, the bezel layer BZ allows only light having specific color to be selectively transmitted/reflected. Also, the bezel layer BZ may be, for example, a light blocking layer that absorbs incident light. The color of the bezel area BZA may be determined according to the light transmittance of the bezel layer BZ.

[0068] The bezel layer BZ may be formed by performing printing or deposition on the rear surface RS of the base substrate BS. Here, the bezel layer BZ may be formed directly on the rear surface RS of the base substrate BS. Alternatively, the bezel layer BZ may be coupled to the rear surface RS of the base substrate BS through a separate adhesive member or the like. Here, the adhesive member may be in contact with the rear surface RS of the base substrate BS.

[0069] FIG. 3b illustrates an image of the front surface FS of the base substrate BS which is captured by a scanning electron microscope SEM. According to the present invention, the roughness of the front surface FS of the base substrate BS may be controlled to a range from about 0.2 nm to about 3 nm. Here, although not illustrated, FIG. 3b may correspond to microscopic images of

the rear surface RS and side surface of the base substrate BS.

[0070] The roughness of the front surface FS and rear surface RS of the base substrate BS represents the surface roughness of the window. The surface roughness of the window may be substantially related to the strength of the window against the external impact.

[0071] Since the surface roughness of the window may be used as a propagation path of crack or the like caused by the external impact as the surface roughness is increased, the strength of the window is likely to be reduced. According to the present invention, the window 100 having the surface roughness in a range of 0.2 nm to 3 nm is provided, and thus, the window 100 and the electronic device EA having the improved strength against the external impact may be provided.

[0072] FIG. 4 is a flowchart schematically illustrating a method of manufacturing a window according to an embodiment of the present invention. FIGS. 5a to 5g are cross-sectional views schematically illustrating a method of manufacturing a window according to an embodiment of the present invention. FIG. 6 is a graph illustrating a change in thickness of an intermediate layer over time during some steps in a method of manufacturing a window. FIG. 7a is a microscopic image of a surface of an intermediate window, and FIG. 7b is a microscopic image of a surface of a window according to an embodiment of the present invention.

[0073] FIGS. 5a to 5g illustrate cross-sectional views in steps corresponding to FIG. 4. Hereinafter, the present invention will be described with reference to FIGS. 4 to 5g. Here, the same reference numerals may be given to the same components as those illustrated in FIGS. 1 to 3b, and their duplicated descriptions will be omitted.

[0074] As illustrated in FIGS. 4, 5a, and 5b, an initial window 100-I is provided (S100). FIG. 5b is an enlarged view illustrating AA' of FIG. 5a for ease of description.

[0075] The initial window 100-I has a predetermined thickness DD-S. The initial window 100-I according to the embodiment may be a glass substrate that contains various inorganic materials. For example, the initial window 100-I may include at least silicon oxide (SiO_2), aluminum oxide (Al_2O_3), lithium oxide (Li_2O), and alkali metal oxide, for example, sodium oxide (Na_2O) or potassium oxide (K_2O), and may also include phosphorus oxide (P_2O_5). In the embodiment, alkali metal ions Na are illustrated as circular particles for ease of description.

[0076] Here, a surface FS-I of the initial window 100-I according to the embodiment may include a plurality of defects DFS. The defects DFS may include scratches or recesses formed in the surface FS-I of the initial window 100-I. The defects DFS may be formed due to the collision to the outside and the contact with the external environment during forming of the initial window 100-I or during moving of the initial window 100-I. The roughness of the surface FS-I of the initial window 100-I may vary according to the number or shape of the defects DFS.

[0077] In the cross-section, a thickness D1 in which

the defects DFS are formed is smaller than the thickness DD-S of the initial window 100-I. For example, the thickness D1 in which the defects DFS are formed may be about 300 nm to about 400 nm.

[0078] Here, the initial window 100-I according to the embodiment may further include predetermined foreign substances SS. The foreign substances SS may be provided while attached to the surface FS-I of the initial window 100-I. The foreign substances SS may include different materials from the initial window 100-I, and include organic materials and/or inorganic materials. Here, this is merely illustrated as an example. There may be no foreign substances SS in the initial window 100-I according to an embodiment of the present invention, and the embodiment is not limited to any one embodiment.

[0079] Then, referring to FIG. 4, the window 100 is formed after a washing step (S200) of washing the initial window 100-I. The washing step (S200) may include an acid washing step (S210) and a base washing step (S220). FIGS. 5c and 5d illustrate cross-sectional views corresponding to the acid washing step (S210) for ease of description and illustrate a region corresponding to FIG. 5b.

[0080] Referring to FIGS. 5c and 5d, the acid washing step (S200) may be to provide the initial window 100-I into an acidic environment. The acidic environment represents an environment having hydrogen exponent (hereinafter, pH) value less than 7, and may be provided in various states such as liquid, gas, or solid as long as it has acidity.

[0081] In the embodiment, the acid washing step (S210) may proceed by immersing the initial window 100-I into an acidic solution WS1. The acidic solution WS1 according to an embodiment of the present invention may be a strong acid having a pH of 2 or lower. For example, the acidic solution WS1 may include at least one of nitric acid (HNO_3), sulfuric acid (H_2SO_4), and hydrochloric acid (HCl). Here, a pH value of the acidic solution WS1 may be measured to be about 2.5 or less at room temperature.

[0082] The acidic solution WS1 reacts with the initial window 100-I, and accordingly, an intermediate layer L2 may be formed in the initial window 100-I. Thus, as illustrated in FIG. 5d, the initial window 100-I is subjected to the acid washing step (S200) and then may be formed to be an intermediate window 100-M which is divided into an intermediate layer L2 and a base layer L1. The intermediate layer L2 may be formed surrounding the surface of the base layer L1.

[0083] The intermediate layer L2 may be formed by removing at least a portion of the alkali metal ions Na of the initial window 100-I through the reaction with the acidic solution WS1. Here, positions Po, from which the alkali metal ions Na move out, may be filled with hydrogen ions provided from the acidic solution WS1 or may be provided as voids.

[0084] As the alkali metal ions Na are removed from the initial window 100-I, a content ratio of silicon to alkali metal ions within the intermediate layer L2 may be greater

than a content ratio of silicon to alkali metal ions within the base layer L1. The content ratio of silicon to alkali metal ions within the base layer L1 may substantially correspond to a content ratio of silicon to alkali metal ions within the initial window 100-I.

[0085] A thickness D2 of the intermediate layer L2 may be at least equal to or greater than the thickness D1 in which the defects DFS illustrated in FIG. 5b are formed. Accordingly, through a subsequent process of removing the intermediate layer L2, the defects DFS may also be stably removed. This will be described later in detail.

[0086] FIG. 6 may correspond to a change in thickness of the intermediate layer L2 during the acid washing step (S210). FIG. 6 illustrates graphs PL1, PL2, and PL3 each showing a change in thickness over time at different temperature conditions during the acid washing step (S210). A first graph PL1 represents a change in thickness of the intermediate layer over time when immersed into the acidic solution under the temperature condition of 40°C, a second graph PL2 represents a change in thickness of the intermediate layer over time when immersed into the acidic solution under the temperature condition of 50°C, and a third graph PL3 represents a change in thickness of the intermediate layer over time when immersed into the acidic solution under the temperature condition of 60°C.

[0087] Referring to the first to third graphs PL1, PL2, and PL3, it may be understood that the thickness of the intermediate layer L2 increases as time passes. Also, it may be understood that as the acid washing step 210 is performed under a higher temperature condition, the thickness of the intermediate layer L2 becomes increased. According to the present invention, as the temperature condition of the acid washing step (S21) becomes higher, a formation speed of the intermediate layer L2 may increase, but vapor is likely to occur. As the temperature condition of the acid washing step (S21) becomes lowered, a formation speed of the intermediate layer L2 may decrease, but the thickness of the intermediate layer L2 may be finely controlled. Thus, the thickness of the intermediate layer L2 may be easily controlled by controlling the temperature condition and time condition of the acid washing step (S210).

[0088] For example, in a case where the acid washing step (S210) is performed for about 5 minutes to about 10 minutes under the temperature condition of about 60°C to about 65°C, the intermediate layer L2 having a thickness range of 200 nm to 500 nm may be formed. Here, this is merely illustrated as an example, and a process time of the acid washing step (S210) may be designed to various times as long as it is about 5 minutes to about 30 minutes. The thickness D2 of the intermediate layer L2 according to the present invention may be variously controlled to correspond to the thickness D1 in which the defects DFS are formed, and the embodiment is not limited to any one embodiment.

[0089] Then, referring to FIGS. 5e to 5g, the window 100 may be formed through a base washing step (S220).

The base washing step (S220) may be to provide the intermediate window 100-M into a basic environment. The basic environment represents an environment having a pH value greater than 7, and may be provided in various states such as liquid, gas, or solid as long as it is a base.

[0090] In the embodiment, the base washing step (S220) may proceed by immersing the intermediate window 100-M into a basic solution WS2. The basic solution WS2 according to an embodiment of the present invention may be a strong base having a pH of 13 or higher. For example, the basic solution WS2 may include sodium hydroxide (NaOH) or potassium hydroxide (KOH).

[0091] The window 100 has a predetermined thickness DD. In the embodiment, the thickness DD of the window 100 may be less than the thickness DD-S of the initial window 100-I. The thickness DD of the window 100 may correspond to the thickness of the base layer L1.

[0092] The basic solution WS2 reacts with the intermediate window 100-M, and the intermediate layer L2 is removed from the intermediate window 100-M, whereby the window 100 may be formed. Here, the defects DFS or the foreign substances SS present in the initial window 100-I (see FIG. 5a) may be removed from the base layer L1 together with the intermediate layer L2.

[0093] Accordingly, the window 100 may have a surface FS with no defects DFS or foreign substances SS. The surface FS of the window 100 may substantially correspond to the surface of the base layer L1. The surface roughness of the window 100 may be within a range of 0.2 nm to 3 nm. The surface roughness of the window 100 may be less than the surface roughness of the initial window 100-I or the surface roughness of the intermediate window 100-M.

[0094] FIG. 7a corresponds to a scanning electron microscope image of the surface of the intermediate window 100-M illustrated in FIG. 5c. That is, FIG. 7a may correspond to the microscopic image of a surface FS-C of the intermediate layer L2. FIG. 7b may correspond to a scanning electron microscope image of the surface FS of the window 100 illustrated in FIG. 5g.

[0095] Referring to FIGS. 7a and 7b, the surface roughness of the window 100 may be less than the surface roughness of the intermediate layer L2. Due to the alkali metal ions eluted out during the acid washing step (S210), the intermediate layer L2 may include a plurality of voids as illustrated in FIG. 7a. The voids may be a main reason for the increase in surface roughness of the intermediate layer L2.

[0096] Then, as illustrated in FIG. 7b, the basic solution may easily permeate the inside the intermediate layer L2 through the voids during the base washing step (S220), and thus, the intermediate layer L2 may be easily removed during the base washing step (S220). Here, the defects DFS or foreign substances SS present in the intermediate layer L2 may be stably removed together with the intermediate layer L2. Accordingly, as illustrated in FIG. 7b, the window 100 may have the lowered surface

roughness.

[0097] As illustrated above, as the thickness of the intermediate layer L2 becomes greater than or equal to the thickness D1 in which the defects DFS are formed, the defects DFS may be easily removed during the washing step (S200).

[0098] According to the present invention, only through the washing step (S200), the surface FS of the window 100 may be formed, from which the defects DFS acting as a propagation path of cracks due to external impact or the foreign substances SS causing a chemical reaction or physical damage are removed. Also, according to the present invention, through only the washing step (S200), the surface FS of the window 100 may have a low roughness, and thus, a post-polishing process may be omitted. Accordingly, a process for manufacturing the window 100 may be simplified, and the window 100 having improved reliability may be easily formed.

[0099] FIG. 8 is a graph showing the strength of the window according to an embodiment of the present invention. FIG. 8 illustrates each of strength evaluation results for a comparative example R1 and first to fourth embodiments E1, E2, E3, and E4 according to the present invention for ease of description. FIG. 8 illustrates result values obtained by a ball drop test which is one of impact resistance evaluating methods. In the embodiment, a steel ball having a weight of 150 g was used. Hereinafter, the present invention will be described with reference to FIG. 8.

[0100] As illustrated in FIG. 8, it was shown that the comparative example R1 has result values distributed in a range of about 20 cm to about 40 cm and has impact resistance against a ball that drops from an average height of about 27.5 cm. The comparative example R1 may represent a window which has not been subjected to the washing step (S200, see FIG. 4) according to an embodiment of the present invention.

[0101] The first to fourth embodiments E1, E2, E3, and E4 may represent windows which have been subjected to the washing step (S200) according to an embodiment of the present invention. The first embodiment E1 may represent a window which has been subjected to the acid washing step (S210, see FIG. 4) for 5 minutes at a temperature of about 60°C and then has been subjected to the base washing step (S220, see FIG. 4) for 5 minutes at a temperature of about 60°C. Here, it was shown that the first embodiment E1 has impact resistance against a ball that drops from an average height of about 60 cm.

[0102] The second embodiment E2 may represent a window which has been subjected to the acid washing step (S210) for 15 minutes at a temperature of about 50°C and then has been subjected to the base washing step (S220) for 15 minutes at a temperature of about 50°C. Here, it was shown that the second embodiment E2 has impact resistance against a ball that drops from an average height of about 62.5 cm.

[0103] The third embodiment E3 may represent a window which has been subjected to the acid washing step

(S210) for 15 minutes at a temperature of about 50°C and then has been subjected to the base washing step (S220) for 20 minutes at a temperature of about 50°C. Here, it was shown that the third embodiment E3 has impact resistance against a ball that drops from an average height of about 80 cm.

[0104] The fourth embodiment E4 may represent a window which has been subjected to the acid washing step (S210) for 30 minutes at a temperature of about 50°C and then has been subjected to the base washing step (S220) for 30 minutes at a temperature of about 50°C. Here, it was shown that the second embodiment E4 has impact resistance against a ball that drops from an average height of about 92.5 cm.

[0105] It was shown that the first to fourth embodiments E1, E2, E3, and E4 have improved impact resistance compared to comparative example R1. That is, according to the present invention, as the washing step (S200) is further performed, the window having improved durability and strength may be easily provided.

[0106] Here, a change according to conditions of the washing step (S200) will be described in more detail by comparing the results between the first to fourth embodiments E1, E2, E3, and E4.

[0107] Referring to the first and second embodiments E1 and E2, the second embodiment E2 was evaluated to have slightly increased impact resistance compared to the first embodiment E1. The second embodiment E2 has been subjected to the acid washing step (S21) and the base washing step (S220) at a lower temperature but for a longer period of time compared to the first embodiment E1.

[0108] According to the present invention, it may be understood that the second embodiment E2 has formed thicker intermediate layer than the first embodiment E1. As described above, a formation speed of the intermediate layer may increase as the temperature of the acid washing step (S210) increases, but it may be understood that the second embodiment E2 has been subjected to the acid washing step (S210) for the longer period of time and thus has formed the intermediate layer having the sufficient thickness compared to the first embodiment E1. Accordingly, defects, which may deteriorate the impact resistance, are sufficiently removed in the second embodiment E2, and thus, relatively high impact resistance may be obtained. Here, taking into consideration that there is no significant difference between the first and second embodiments E1 and E2, the window having sufficient strength may be formed through only the conditions of the washing step (S200) performed on the fourth embodiment E1.

[0109] Referring to the second and third embodiments E2 and E3, the third embodiment E3 was evaluated to have higher impact resistance compared to the second embodiment E2. Also, it was shown that the third embodiment E3 has small variation in result values compared to the other embodiments E1, E2, and E4. The third embodiment E3 has been subjected to the same

acid washing step (S210) as the second embodiment E2, but has been subjected to the base washing step (S220) for a longer period of time.

[0110] According to the present invention, an amount of the intermediate layer to be removed may be different between the third embodiment E3 and the second embodiment E2. The second embodiment E2 is subjected to the base washing step (S220) for a relatively shorter period of time, and thus, a portion of the intermediate layer formed during the acid washing step (S210) may not be removed but remain. The remaining intermediate layer may affect the impact resistance. The third embodiment E3 has been subjected to the base washing step (S220) for a longer period of time, and thus, all of the formed intermediate layer may be removed to exhibit the improved strength.

[0111] Referring to the third and fourth embodiments E3 and E4, the fourth embodiment E4 was evaluated to have the improved impact resistance compared to the third embodiment E3. The fourth embodiment E4 has been subjected to the acid washing step (S200) at the same temperature as the third embodiment E3 but for a longer period of time than the third embodiment E3.

[0112] According to the present invention, it may be understood that the fourth embodiment E4 has formed thicker intermediate layer than the third embodiment E3. Also, the fourth embodiment E4 has been subjected to the base washing step (S220) for a longer period of time than the third embodiment E3, and thus, it may be understood that a thicker intermediate layer than the third embodiment E3 has been formed but entirely removed during the base washing step (S220). Accordingly, defects, which may deteriorate the impact resistance, are sufficiently removed in the fourth embodiment E4, and thus, relatively high impact resistance may be obtained.

[0113] According to the present invention, the intermediate layer having the thickness sufficient to remove the defects is formed through the acid washing step, and the intermediate layer is removed through the base washing step, whereby the window having the improved strength may be provided. Also, according to the present invention, windows having various impact resistance may be easily secured by designing the temperature conditions or time conditions of the washing step. Accordingly, the window may be provided, which simplifies processes and has the improved strength.

[0114] FIG. 9 is a flowchart illustrating a method of manufacturing a window according to an embodiment of the present invention. FIGS. 10a to 10c are perspective views illustrating a method of manufacturing a window according to an embodiment of the present invention. FIGS. 11a to 11c are perspective views illustrating a method of manufacturing a window according to an embodiment of the present invention. Hereinafter, the present invention will be described with reference to FIGS. 9 to 11c. Here, the same reference numerals may be given to the same components as those illustrated in FIGS. 1 to 8, and their duplicated descriptions will be

omitted.

[0115] As illustrated in FIG. 9, an initial window providing step (S100-1) may include a mother substrate providing step (S110), a cutting step (S120), a chamfering step (S130), and a strengthening step (S140). FIGS. 10a to 10c schematically illustrate the mother substrate providing step (S110), the cutting step (S120), and the chamfering step (S130).

[0116] Referring to FIGS. 10a and 10b, a mother substrate 100M may be cut to form a plurality of unit substrates 100S. The mother substrate 100M is cut along a virtual cutting lines CL formed on the mother substrate 100M. The cutting step (S120) may be performed using laser or knife.

[0117] Subsequently, as illustrated in FIG. 10c, the unit substrates 100S are chamfered to form a plurality of processed substrates 100-S. The edges of each of the unit substrates 100S are cut (chamfered) through the chamfering step (S130), and thus, the processed substrates 100-S having inclined surfaces PLS may be formed.

[0118] FIGS. 11a to 11c schematically illustrate the strengthening step (S140). Referring to FIG. 11a, an insulating substrate 100-S is provided. The insulating substrate 100-S may include glass. In the embodiment, the insulating substrate 100-S may correspond to any one of the processed substrates described above. In the embodiment, a portion of the insulating substrate 100-S is illustrated on a plane defined by a second direction D2 and a third direction D3 for ease of description.

[0119] The insulating substrate 100-S includes a first surface S1 and a second surface S2 which are opposed to each other in a thickness direction of the insulating substrate 100-S, i.e., the third direction D3. The insulating substrate 100-S may include a base material MD and a plurality of first ions Na⁺. In the embodiment, the first ions Na⁺ may include sodium ions. The first ions Na⁺ may be dispersed within the base material MD.

[0120] Here, the insulating substrate 100-S may include silicon oxide (SiO₂), aluminum oxide (Al₂O₃), lithium oxide (Li₂O), and alkali metal oxide, for example, sodium oxide (Na₂O) or potassium oxide (K₂O), and may also include phosphorus oxide (P₂O₅). An initial window panel 100-I according to an embodiment of the present invention is not limited to a material and includes a glass substrate made of various materials, and the embodiment is not limited to any one embodiment.

[0121] Subsequently, as illustrated in FIG. 11b, the insulating substrate 100-S is immersed into a metal salt, and thus, the insulating substrate 100-S is strengthened. In the embodiment, the strengthening step for the insulating substrate 100-S may be chemical strengthening. In particular, the insulating substrate 100-S may be strengthened through an ion exchange method.

[0122] The metal salt may include second ions K⁺ different from the first ions Na⁺. The second ions K⁺ may have a diameter greater than that of the first ions Na⁺. Here, the second ions may include alkali metal ions. In the embodiment, the second ions K⁺ may include potas-

sium ions K⁺.

[0123] The second ions K⁺ may be substituted by the first ions Na⁺. In the embodiment, the substitution between the second ions K⁺ and the first ions Na⁺ may be made one-to-one. Accordingly, some of the alkali metal ions contained in the metal salt may be exchanged with the first ions Na⁺ and dispersed within a medium MD

[0124] The metal salt may be provided in various forms. For example, the metal salt may be provided in the melted liquid phase of ion salt. Here, in the embodiment, the metal salt may be provided in the form of a single salt or a mixture of salts.

[0125] Referring to FIG. 11c, the insulating substrate 100-S may be formed into an initial window 100-I1 through the strengthening step. The initial window 100-I1 may include a medium MD, and the second ions K⁺ is the first ions Na⁺ dispersed in the medium MD

[0126] In the embodiment, internal stress may be generated in the initial window 100-I1 by the second ions K⁺. As described above, the second ions K⁺ have the diameter greater than that of the first ions Na⁺. Accordingly, the internal stress generated by the second ions K⁺ may be compressive stress. In FIG. 11c, for ease of description, the region, in which the compressive stress is generated, is illustrated as a shaded region, and a center line CTR passing through the center of the thickness DD-S is indicated by an alternate long and short dash line.

[0127] In the initial window 100-I1 as illustrated in FIG. 11c, the compressive stress due to the second ions K⁺ may be present within a range from the first surface S1 to a first depth WD1. Similarly, the compressive stress due to the second ions K⁺ may be present within a range from the second surface S2 to a second depth WD2. Each of the first depth WD1 and the second depth WD2 may substantially correspond to a depth of compression (DOC) of the initial window 100-I1. That is, the initial window 100-I1 may have a stress behavior showing the compressive stress in regions from the surfaces S1 and S2 to the first depth WD1 and the second depth WD2 and showing the tensile stress in regions beyond the first depth WD1 and the second depth WD2.

[0128] Here, FIG. 11c illustrates a maximum depth to which the second ions K⁺ permeate the inside a window panel 100. In particular, the depth to which the second ions K⁺ permeate from the first surface S1 is indicated by a first distance DS1, and the depth to which the second ions K⁺ permeate from the second surface S2 is indicated by a second distance DS2. Each of the first distance DS1 and the second distance DS2 may substantially correspond to a depth of layer (DOL) of the initial window 100-I1.

[0129] According to the present invention, through the strengthening step (S140), the initial window 100-I1 may have regions which generate the compressive stress on the surfaces S1 and S2. Accordingly, the initial window 100-I1 may have improved strength and impact resistance compared to the insulating substrate 100-S.

[0130] Referring to FIG. 10 again, the initial window

100-I1 according to the present invention may be a substrate which has been subjected to the strengthening step (S140). Subsequently, through a washing step (S200), the initial window 100-I1 may have further improved strength. Here, in the embodiment, the window having the improved strength may be provided through only the washing step (S200) without a separate post-polishing process after the strengthening step (S140). Thus, according to the present invention, the window having the improved reliability may be easily provided. Also, the processes may be simplified, and process costs may be reduced.

[0131] Also, in the embodiment, the strengthening step (S140) may be omitted. Here, one of the processed substrates 100-S illustrated in FIG. 10c may be provided to the washing step (S200). Also, in the embodiment, the cutting step (S120) or the chamfering step (S130) may be omitted. The initial window providing step (S100-1) according to an embodiment of the present invention may provide various types of glass substrates, and the embodiment is not limited to any one embodiment.

[0132] FIG. 12 is a perspective view illustrating a window according to an embodiment of the present invention. FIGS. 13a and 13b are perspective views illustrating windows according to an embodiment of the present invention. Hereinafter, the present invention will be described with reference to FIGS. 12 to 13b. Here, the same reference numerals may be given to the same components as those illustrated in FIGS. 1 to 11c, and their duplicated descriptions will be omitted.

[0133] As illustrated in FIG. 12, a window 100-C may have one side which is bent about a predetermined bending axis BX. In the embodiment, the bending axis BX may extend in a second direction D2 and may be provided in a rear surface of the window 100-C. Here, both sides of the window 100-C, which extend in the second direction D2 and face each other in a first direction D1, may be bent about the bending axis BX. According to the present invention, the window 100-C having the bent shape may also have improved strength through the washing step (S200, see FIG. 4) described above.

[0134] Also, as illustrated in FIGS. 13a and 13b, a window 100-F1 and a window 100-F2 may be folded or unfolded about a folding axis FX. For ease of description, FIG. 13a illustrates the window 100-F1 in an unfolded state, and FIG. 13b illustrates the window 100-F2 in a folded state.

[0135] The folding axis FX may extend in a first direction D1 and may be defined on a front surface FS of the window 100-F1. According to the present invention, the windows 100-F1 and 100-F2, of which shapes are deformable during use, may also have improved strength through the washing step (S200).

[0136] According to the present invention, the sufficient impact resistance and strength may be achieved in the window 100-C having the various shapes and in the windows 100-F1 and 100-F2 having the deformable shapes. Accordingly, the window applicable to various

electronic devices may be provided.

[0137] Although described with reference to exemplary embodiments of the present invention, it will be understood that various changes and modifications of the present invention may be made by one ordinary skilled in the art or one having ordinary knowledge in the art without departing from the spirit and technical field of the present invention as hereinafter claimed.

[0138] Hence, the technical scope of the present invention is not limited to the detailed description in the specification but should be determined only in accordance with the appended claims.

INDUSTRIAL APPLICABILITY

[0139] In using an electronic device, a window is essential to protect an electronic panel from external impact. Thus, the present invention relating to the window has high industrial applicability.

Claims

1. A window comprising:

a base substrate comprising a front surface and a rear surface; and
a bezel layer disposed on the rear surface of the base substrate,
wherein the front surface has a roughness in a range of 0.2 nm to 3 nm.

2. The window of claim 1, wherein the base substrate comprises glass.

3. The window of claim 1, wherein the base substrate comprises a lithium oxide (Li_2O).

4. The window of claim 3, wherein the base substrate further comprises a phosphorus oxide (P_2O_4).

5. The window of claim 2, wherein compressive stress is applied within a range from the front surface to a predetermined depth in a thickness direction of the base substrate.

6. The window of claim 1, wherein a predetermined bending axis is defined, which extends in a direction crossing a thickness direction of the base substrate, and
at least a portion of the base substrate is bending about the bending axis.

7. A method of manufacturing a window comprising:

a step of providing an initial window which comprises glass and comprises a lithium oxide; and
a washing step of washing the initial window,

wherein the washing step comprises:

an acid washing step of providing the initial window into an acidic environment; and
a base washing step of providing the initial window, which has been subjected to the acid washing step, into a basic environment.

8. The method of claim 7, wherein the acidic environment has a pH of 2 or lower.

9. The method of claim 8, wherein the acidic environment comprises an acidic solution comprising at least one of nitric acid (HNO_3), sulfuric acid (H_2SO_4), or hydrochloric acid (HCl).

10. The method of claim 9, wherein the acid washing step is performed for about 5 minutes to 10 minutes at a temperature of 60°C to 65°C.

11. The method of claim 7, wherein the basic environment has a pH of 13 or higher.

12. The method of claim 11, wherein the basic environment comprises a basic solution comprising at least one of sodium hydroxide (NaOH) or potassium hydroxide (KOH).

13. The method of claim 7, wherein the window, which has been subjected to the acid washing step, comprises:

a first layer which comprises an alkali metal and silicon that has a predetermined content ratio with respect to the alkali metal; and
a second layer which is formed on a surface of the first layer and has a higher silicon content ratio than the first layer.

14. The method of claim 13, wherein the second layer is formed at a portion of the initial window, from which the alkali metal is eluted out during the acid washing step.

15. The method of claim 14, wherein a thickness of the second layer is 200 nm to 500 nm.

16. The method of claim 15, wherein the base washing step forms a window by removing the second layer from the first layer.

17. The method of claim 7, wherein a surface roughness of the window is less than or equal to a surface roughness of the initial window.

18. The method of claim 17, wherein a surface roughness of the window, which has been subjected to the

acid washing step, is greater than or equal to a surface roughness of the initial window.

19. The method of claim 7, wherein the step of providing the initial window comprises the steps of:

providing a glass substrate; and
strengthening the glass substrate,
wherein the step of strengthening comprises an
ion exchange treatment, and
the step of providing the initial window is to provide strengthened glass substrate.

20. The method of claim 19, wherein the step of providing the initial window further comprises the steps of:

providing a mother substrate;
forming a plurality of unit substrates by cutting the mother substrate; and
chamfering side surfaces of the unit substrates,
wherein the glass substrate is one of the unit substrates which have been subjected to the step of chamfering.

21. A method of manufacturing a window, the method comprising the steps of:

chemically strengthening a glass substrate so that a first initial substrate is formed;
washing the first initial substrate with an acidic solution by providing the first initial substrate into the acidic solution so that a second initial substrate is formed; and
washing the second initial substrate with a basic solution by providing the second initial substrate into the basic solution so that a window is formed,
wherein a roughness of the window ranges from 0.2 nm to 3 nm.

22. The method of claim 21, wherein the glass substrate comprises a lithium oxide.

23. The method of claim 21, wherein the step of chemically strengthening does not comprise potassium carbonate (K_2CO_3), sodium carbonate (Na_2CO_3), potassium bicarbonate ($KHCO_3$), sodium bicarbonate ($NaHCO_3$), potassium phosphate (K_3PO_4), sodium phosphate (Na_3PO_4), potassium sulfate (K_2SO_4), sodium sulfate (Na_2SO_4), and potassium hydroxide (KOH).

24. The method of claim 23, wherein the second initial substrate is formed by eluting out an alkali metal from the first initial substrate.

25. The method of claim 24, wherein the second initial substrate comprises a first layer, which has substan-

tially the same content ratio of silicon to the alkali metal as the first initial substrate, and a second layer, which is formed on a surface of the first layer and has a higher content ratio of the silicon to the alkali metal than the first layer.

26. The method of claim 25, wherein the second layer has relatively higher pores than the first layer.

27. The method of claim 25, wherein the window is formed by removing the second layer from the second initial substrate.

FIG. 1

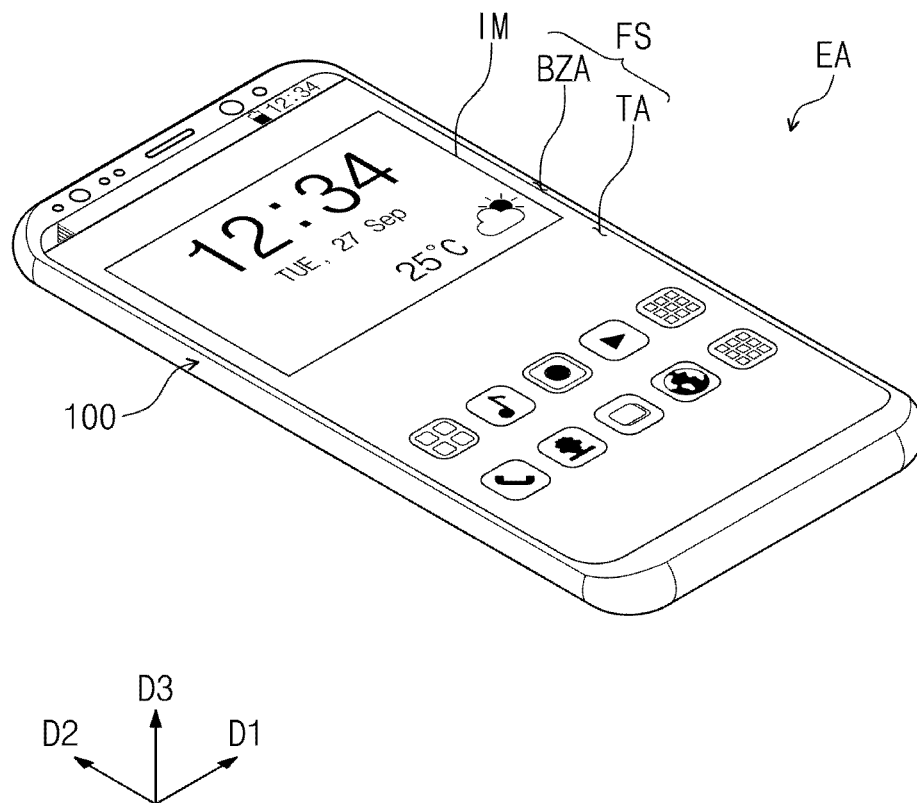


FIG. 2A

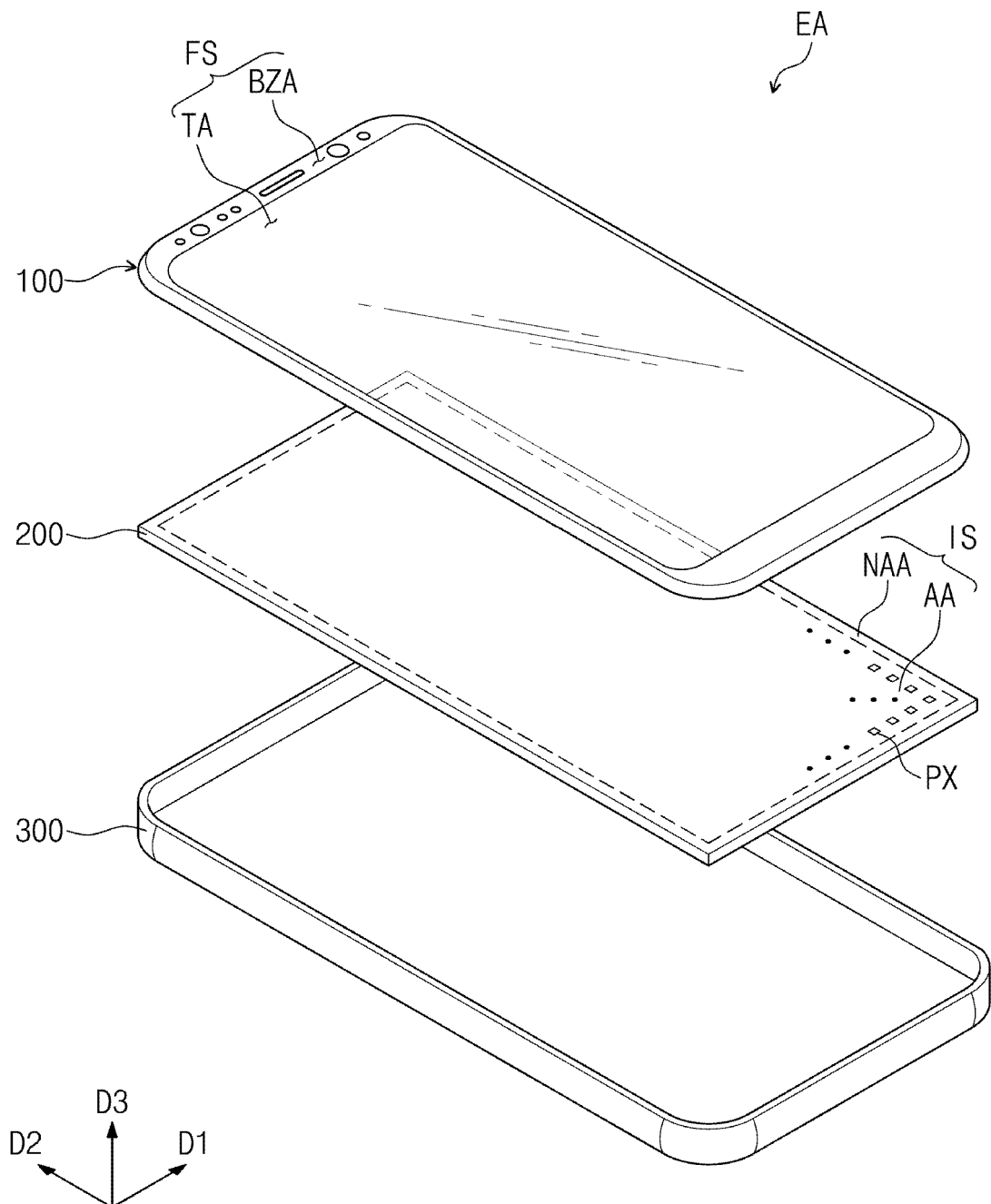


FIG. 2B

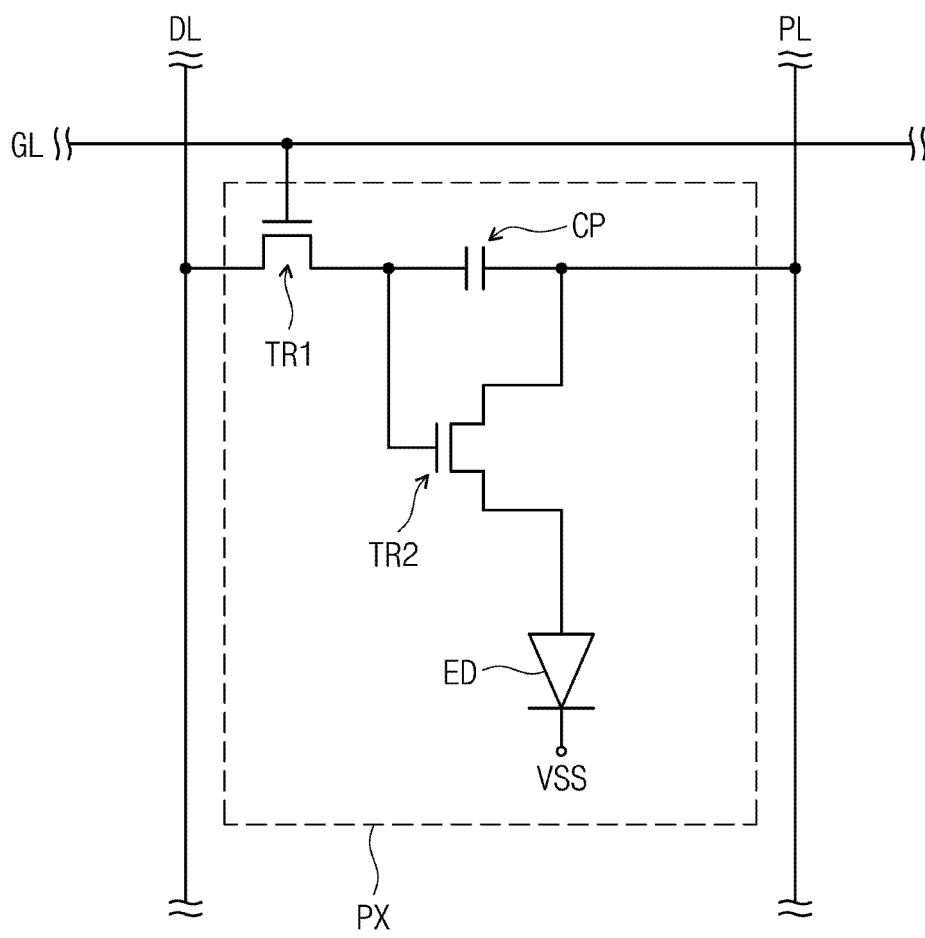


FIG. 3A

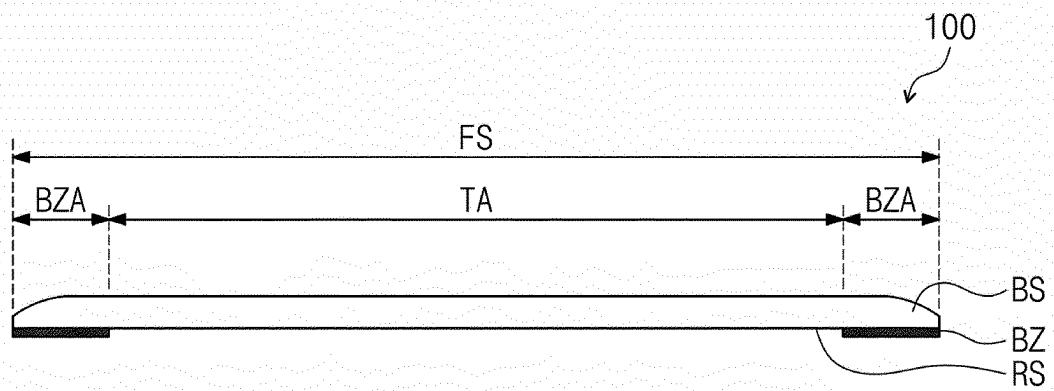


FIG. 3B

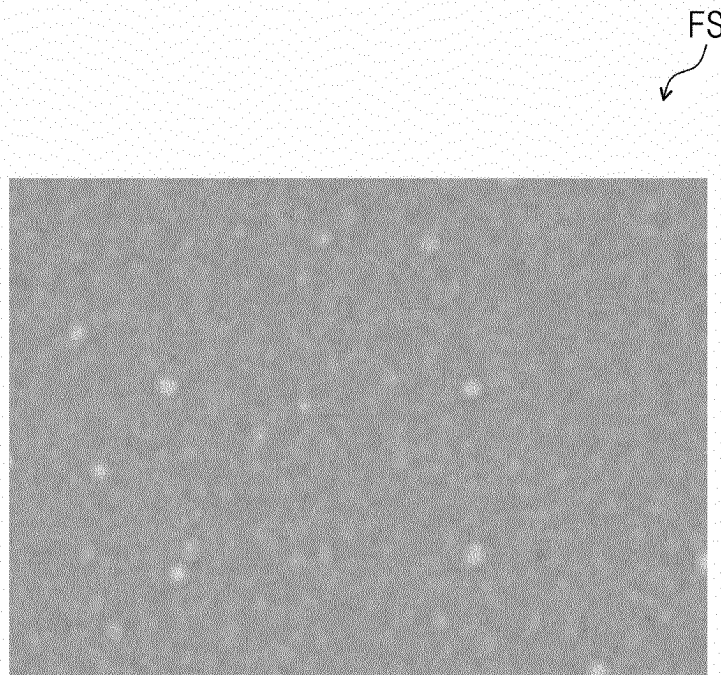


FIG. 4

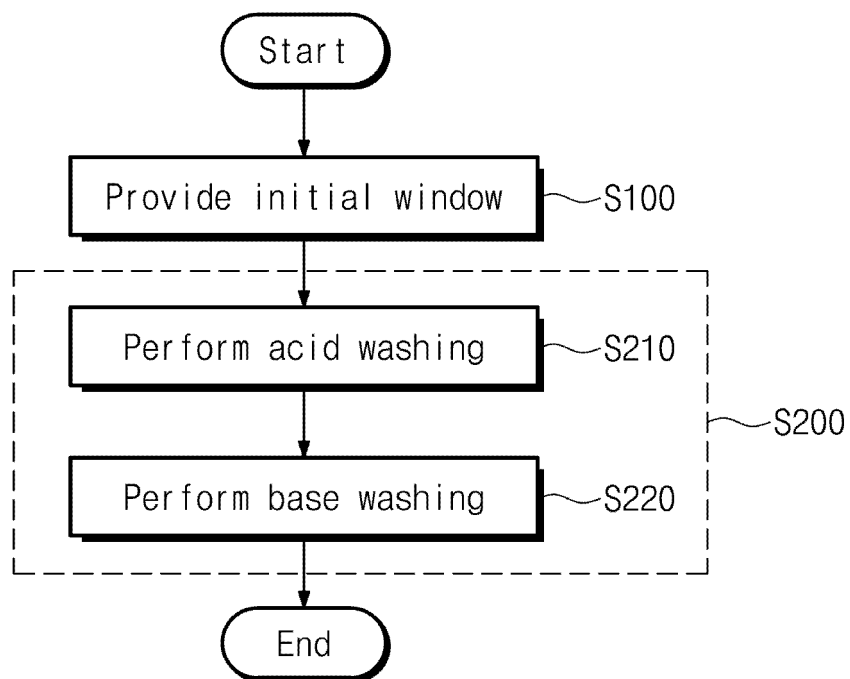


FIG. 5A

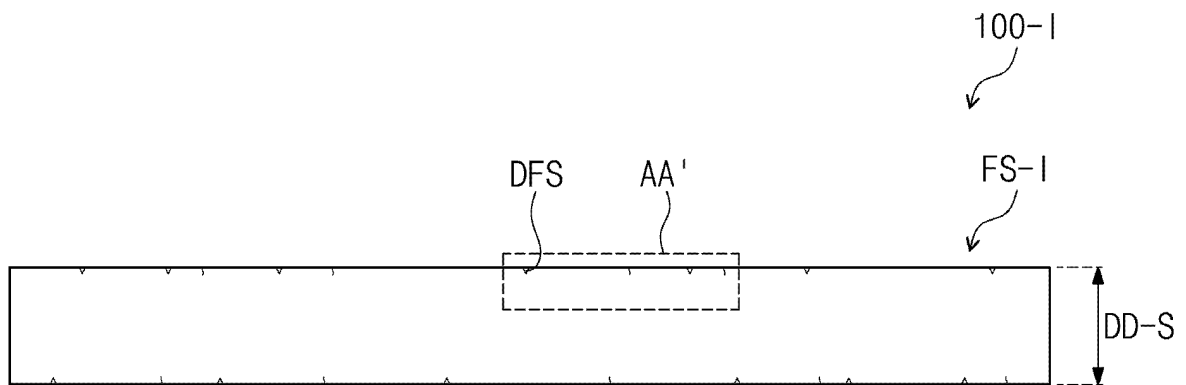


FIG. 5B

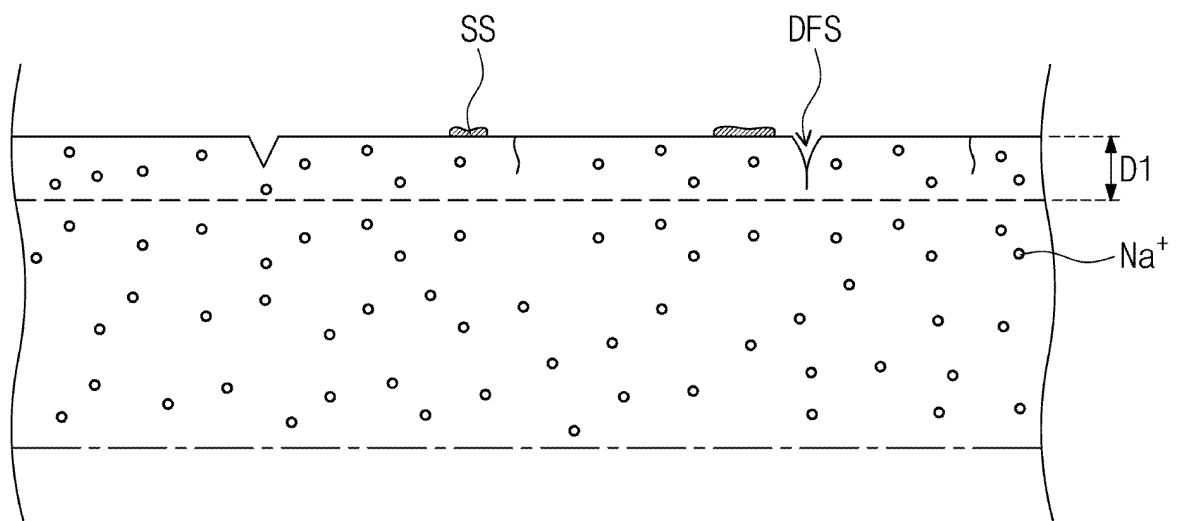


FIG. 5C

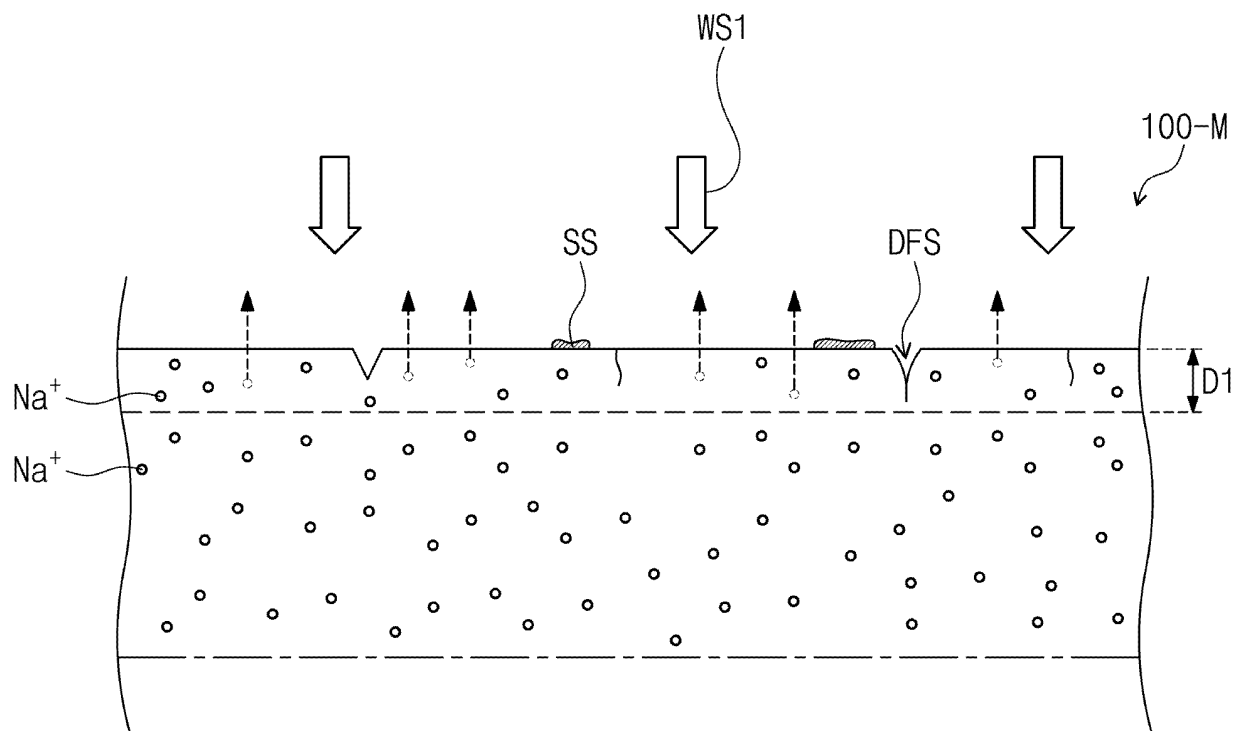


FIG. 5D

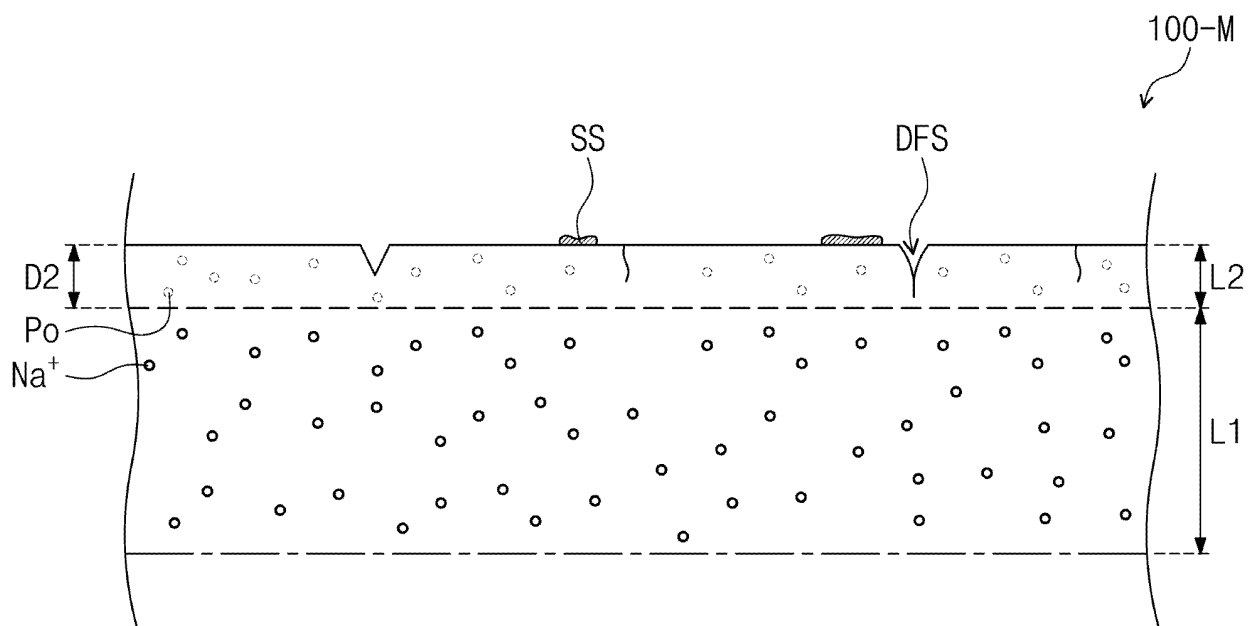


FIG. 5E

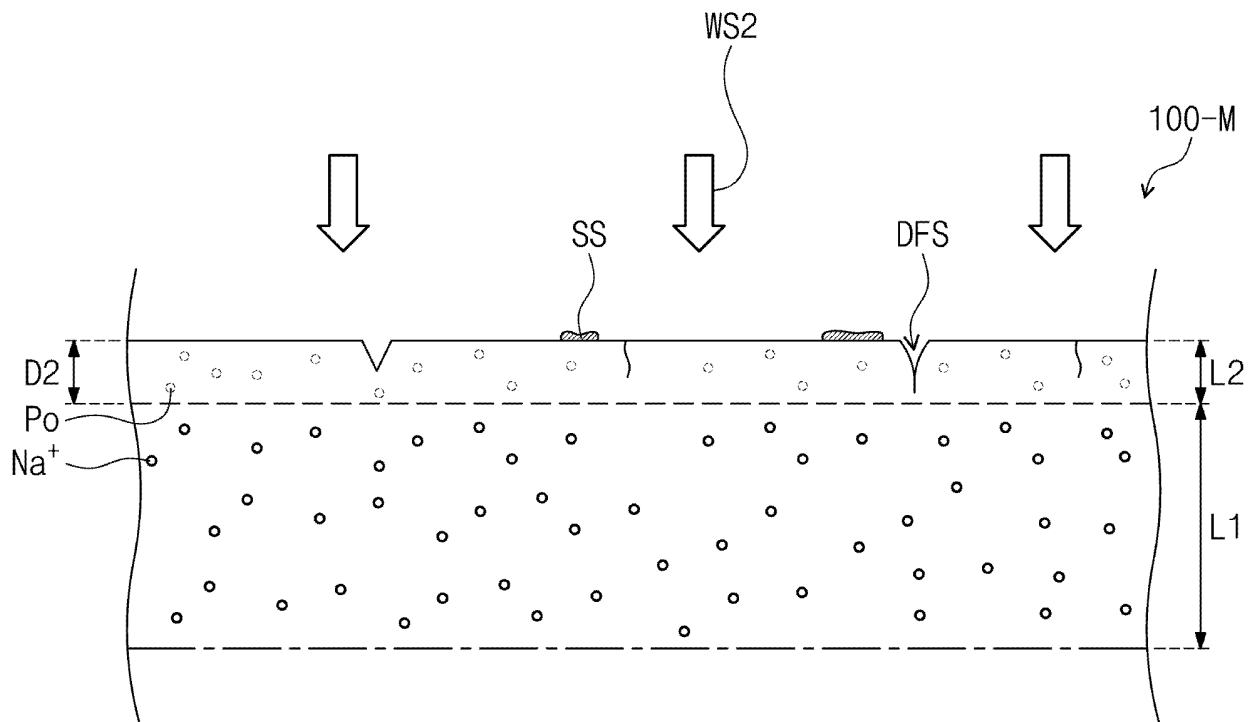


FIG. 5F

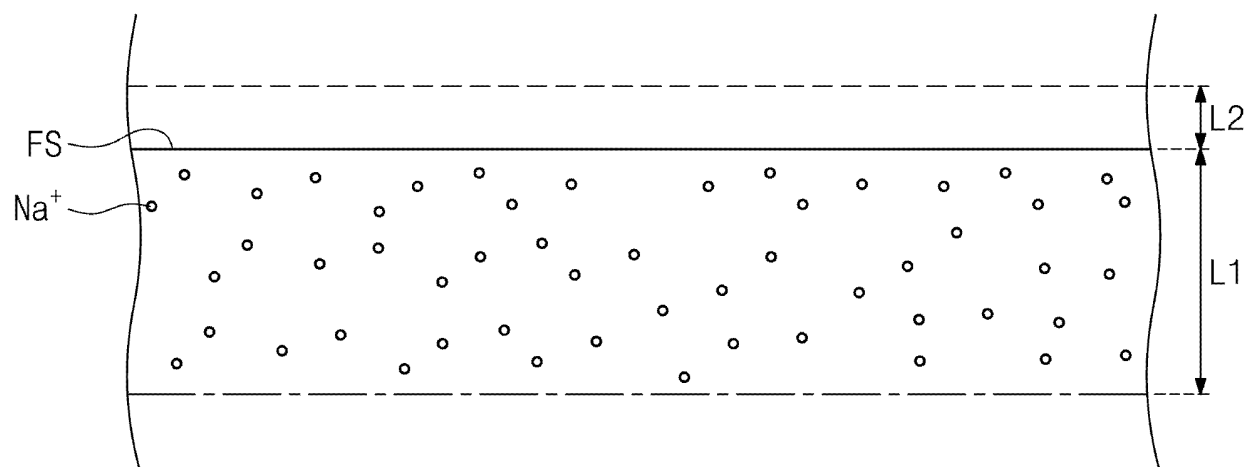


FIG. 5G

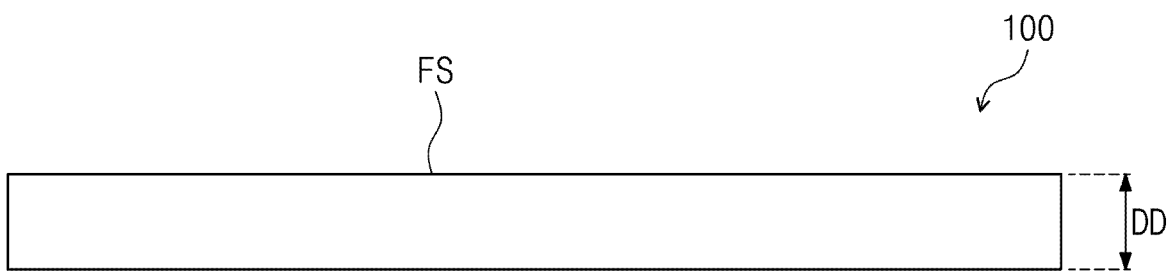


FIG. 6

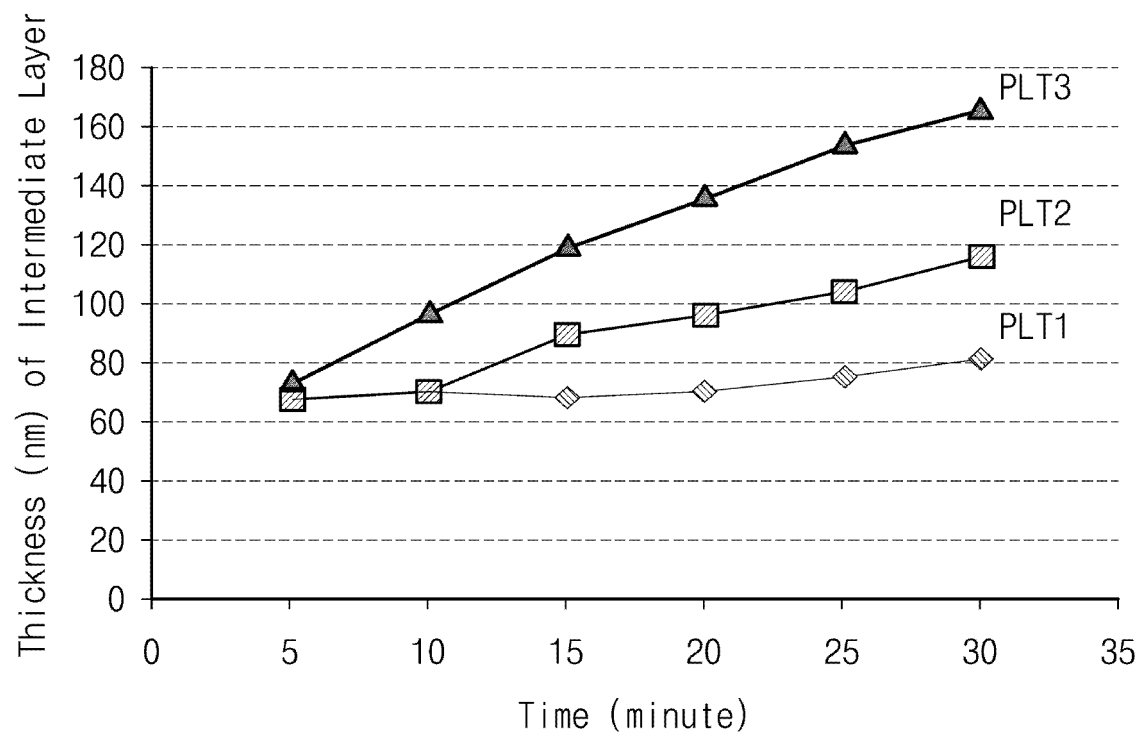


FIG. 7A

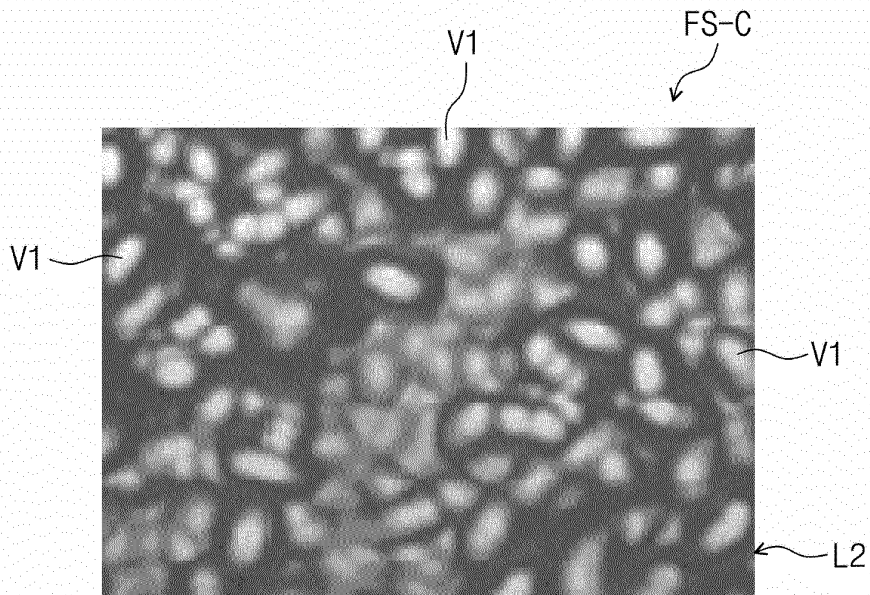


FIG. 7B

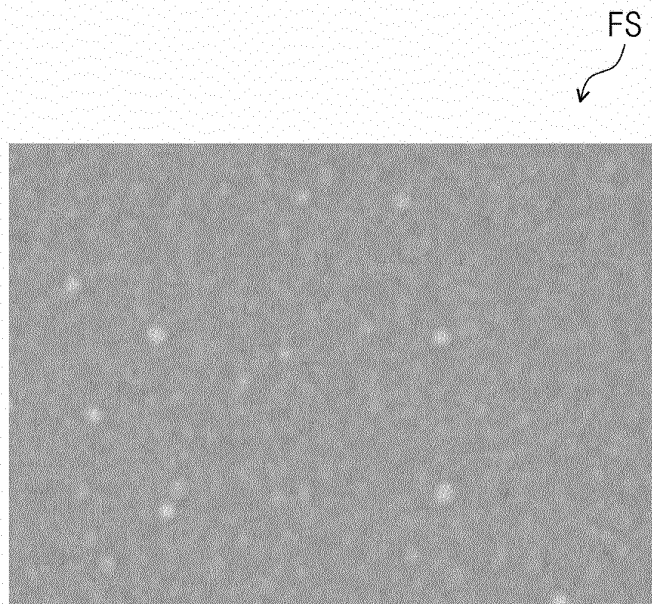


FIG. 8

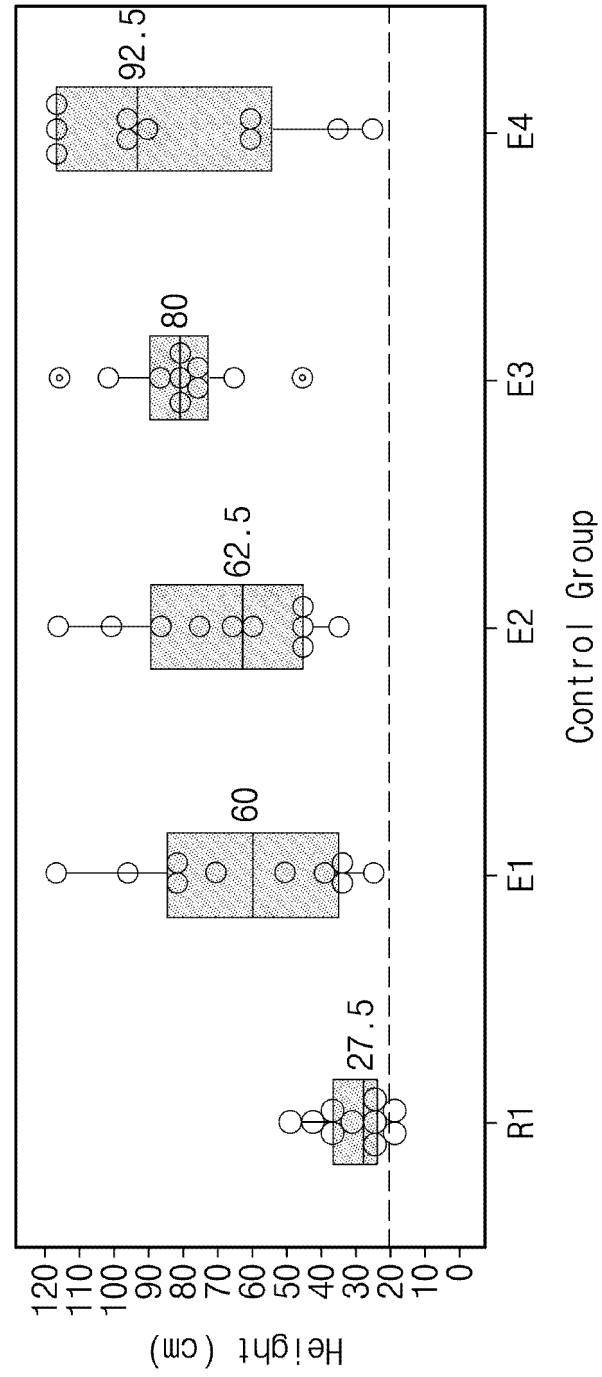


FIG. 9

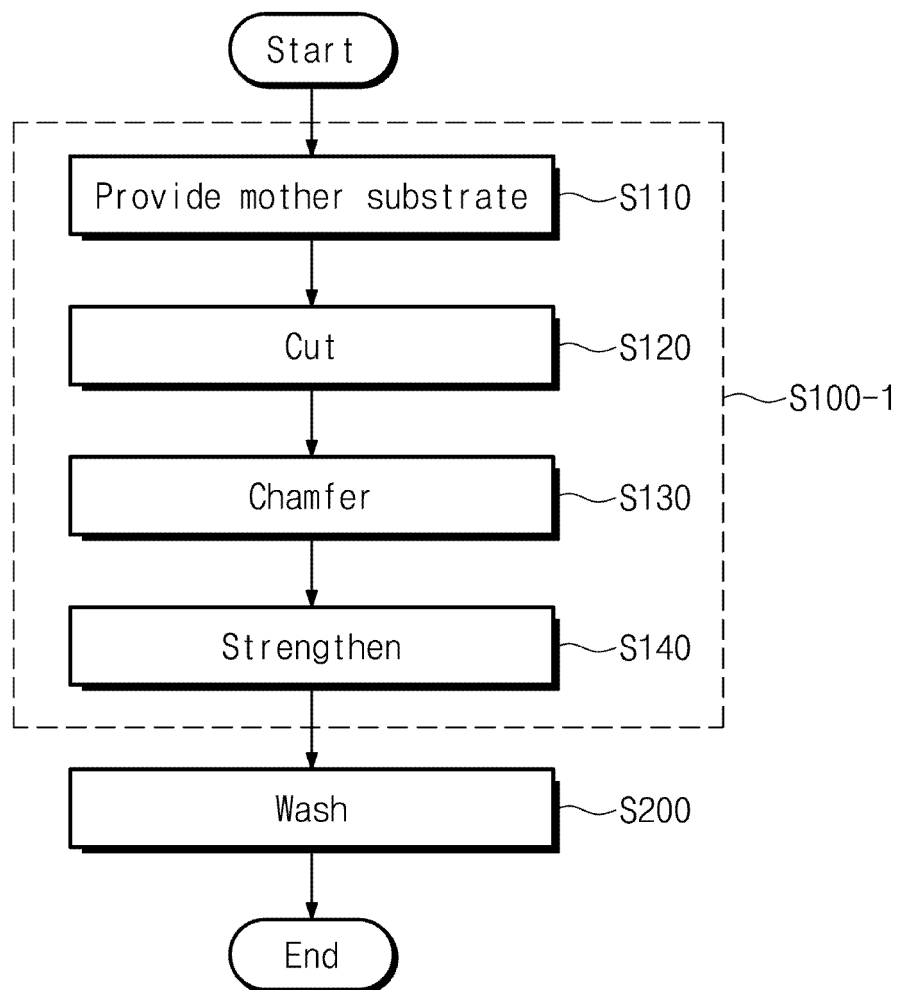


FIG. 10A

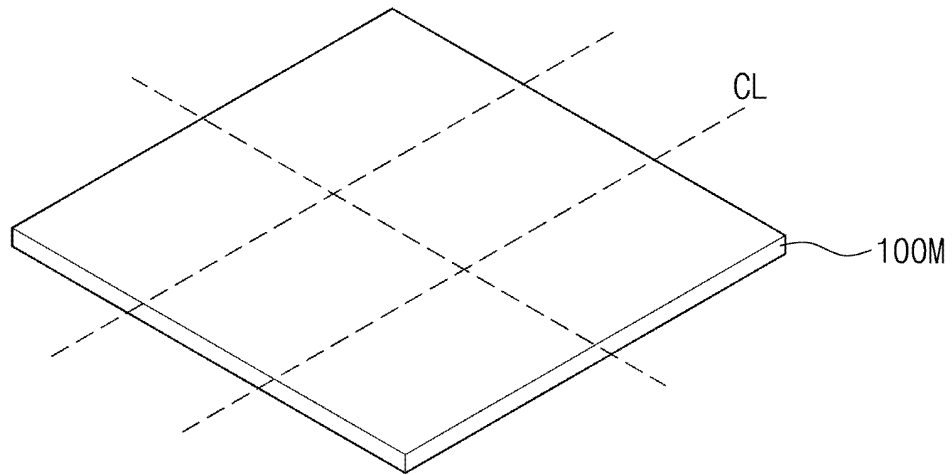


FIG. 10B

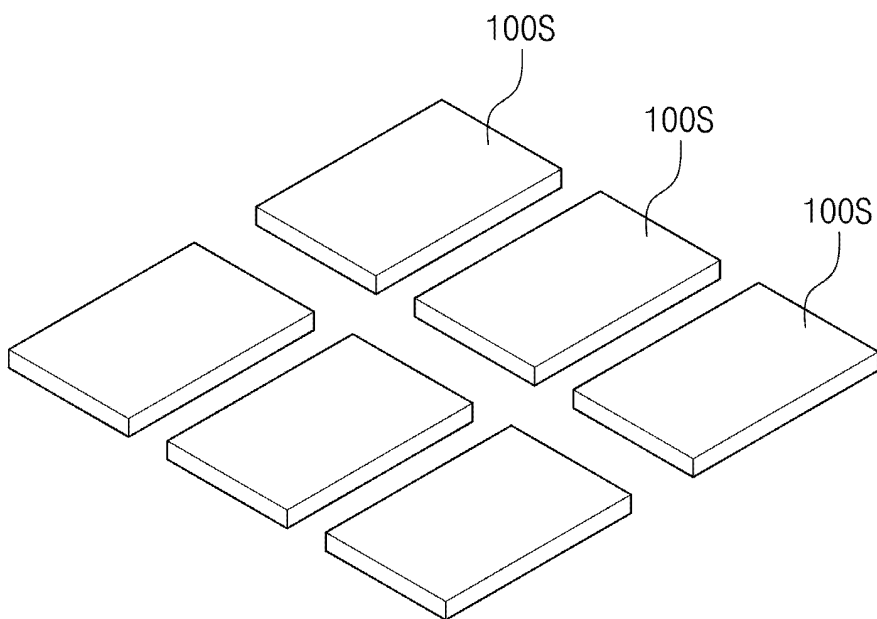


FIG. 10C

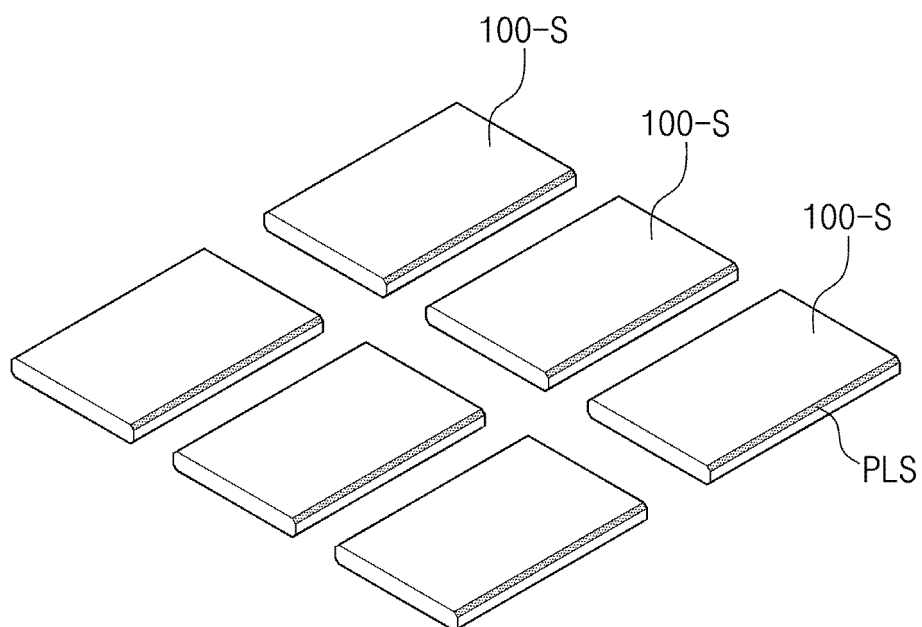


FIG. 11A

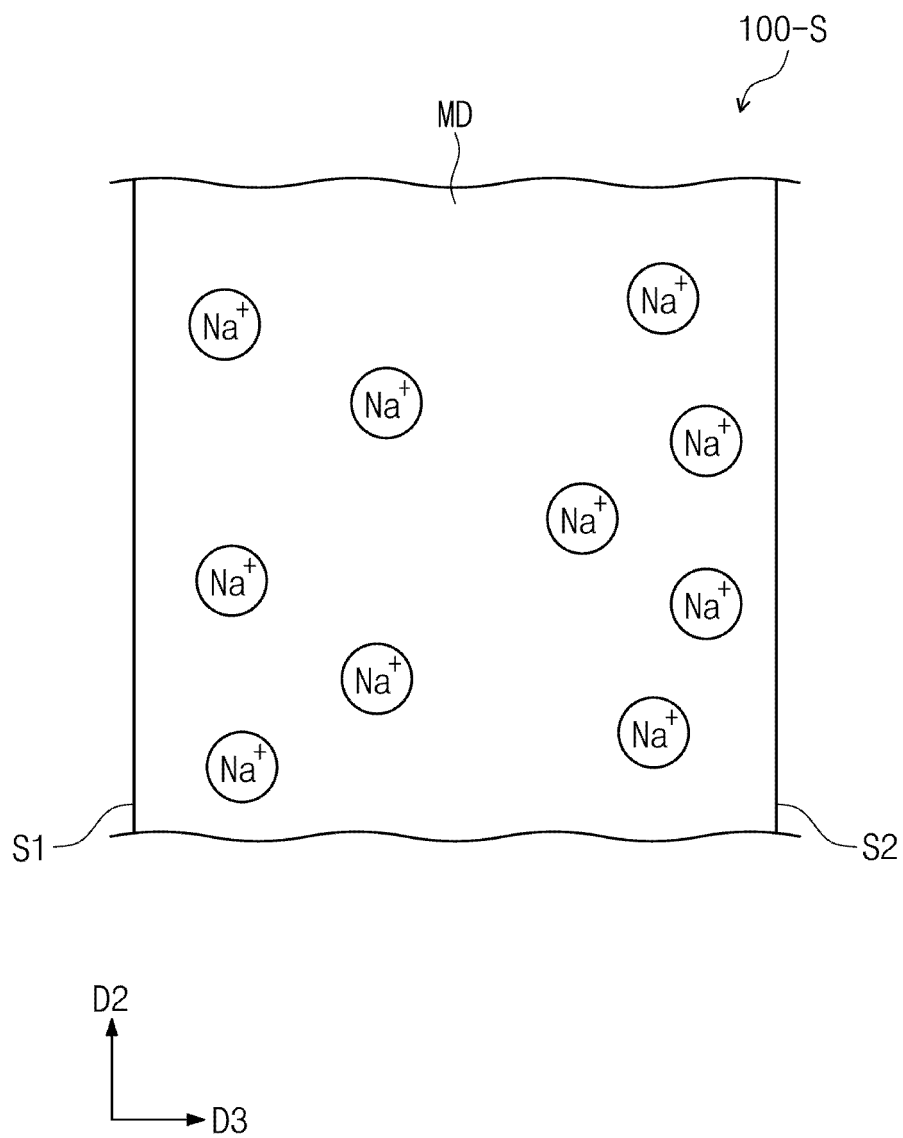


FIG. 11B

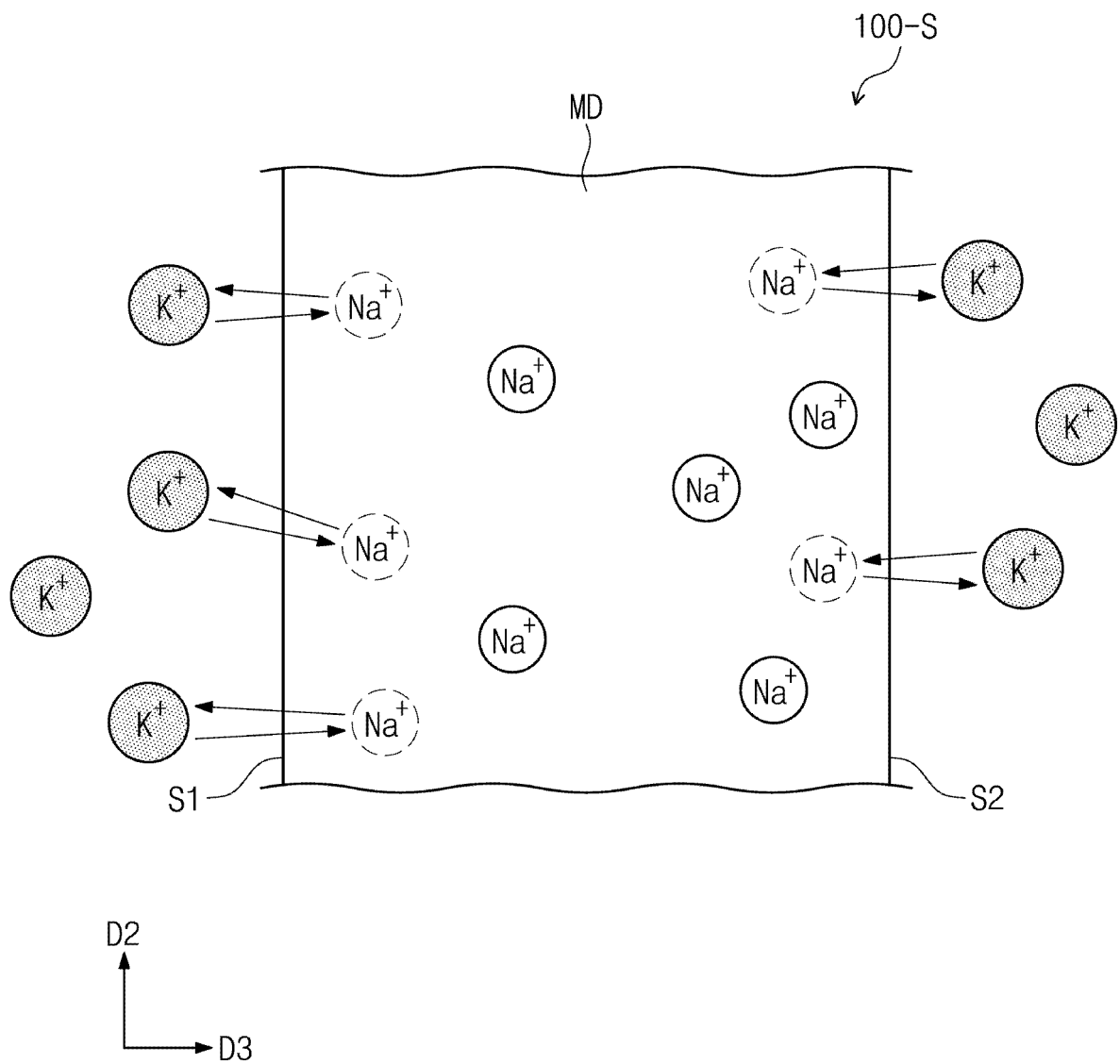


FIG. 11C

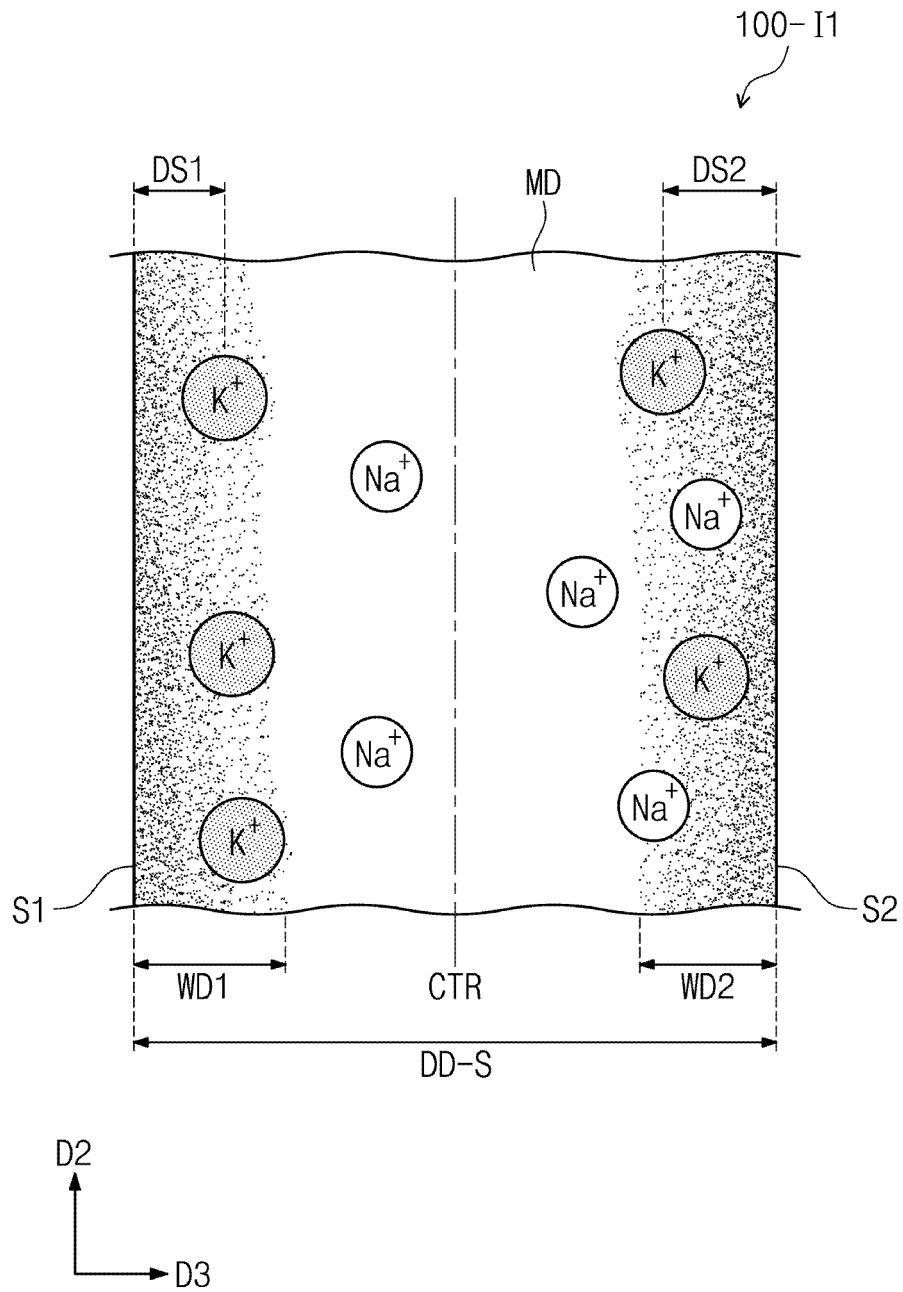


FIG. 12

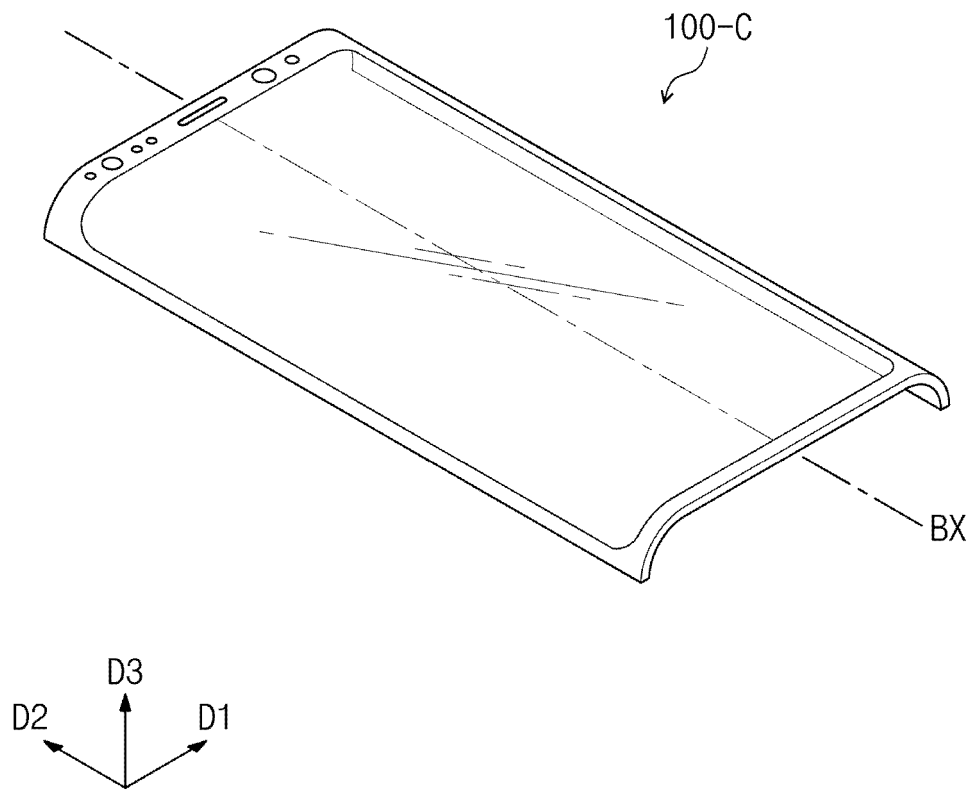


FIG. 13A

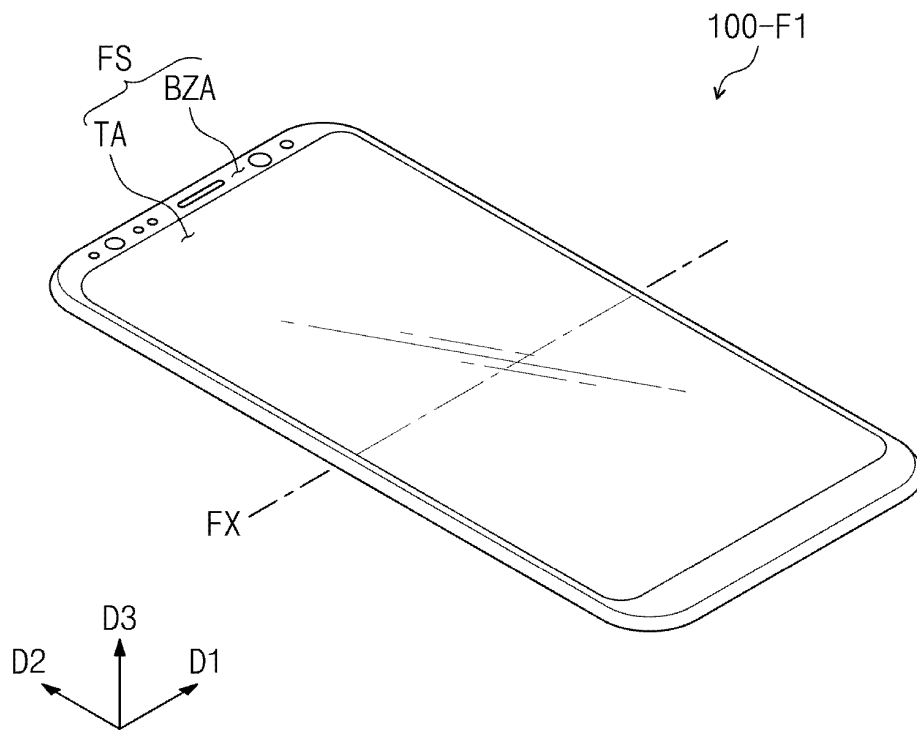
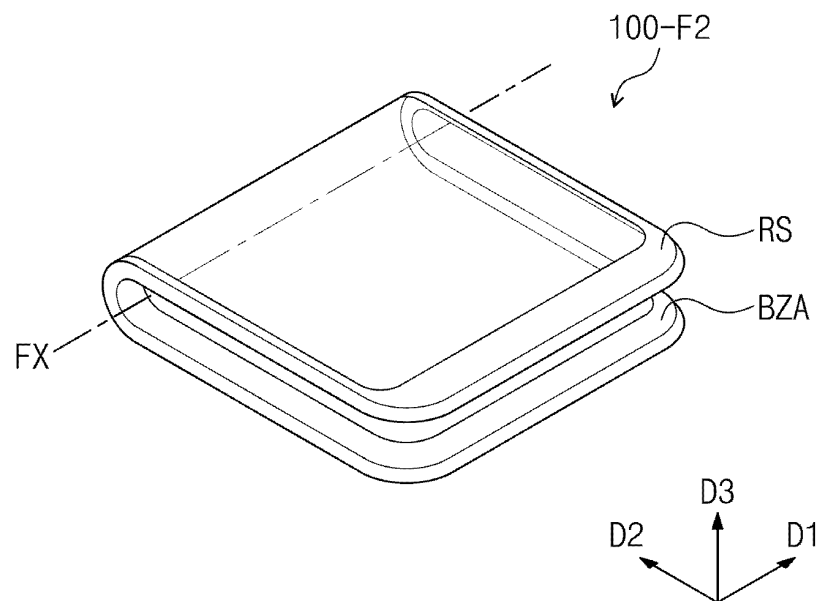


FIG. 13B



INTERNATIONAL SEARCH REPORT

International application No.

PCT/KR2019/004927

A. CLASSIFICATION OF SUBJECT MATTER

H04M 1/02(2006.01)i, C03C 17/30(2006.01)i, C03C 23/00(2006.01)i, C03C 21/00(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

H04M 1/02; B08B 1/00; B32B 17/06; B32B 27/20; B32B 3/30; C03C 21/00; C03C 23/00; C03C 3/085; C03C 4/00; C11D 1/44; C03C 17/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models: IPC as above

Japanese utility models and applications for utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS (KIPO internal) & Keywords: window, bezel, roughness, washing, chemical strengthening

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	KR 10-2018-0083907 A (CORNING INCORPORATED) 23 July 2018 See paragraphs [0004], [0012]-[0073], claims 1-3 and figure 1.	1-6
Y		7-27
Y	JP 2001-206737 A (NIPPON SHEET GLASS CO., LTD.) 31 July 2001 See paragraphs [0018]-[0052] and claims 1-5.	7-27
A	KR 10-2010-0120683 A (CORNING INCORPORATED) 16 November 2010 See paragraphs [0033]-[0046] and claims 1-5.	1-27
A	KR 10-2015-0087224 A (ASAHI GLASS CO., LTD. et al.) 29 July 2015 See paragraphs [0020]-[0041] and claims 1-5.	1-27
A	KR 10-2018-0084674 A (TAIYO INK MFG. CO., LTD.) 25 July 2018 See paragraphs [0183]-[0186] and claims 1-2.	1-27

☐ Further documents are listed in the continuation of Box C.
 ☒ See patent family annex.

* Special categories of cited documents:

“A” document defining the general state of the art which is not considered to be of particular relevance

“E” earlier application or patent but published on or after the international filing date

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“O” document referring to an oral disclosure, use, exhibition or other means

“P” document published prior to the international filing date but later than the priority date claimed

“T” later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

“X” document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

“Y” document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

“&” document member of the same patent family

Date of the actual completion of the international search

10 OCTOBER 2019 (10.10.2019)

Date of mailing of the international search report

10 OCTOBER 2019 (10.10.2019)

Name and mailing address of the ISA/KR


 Korean Intellectual Property Office
 Government Complex Daejeon Building 4, 189, Cheongsu-ro, Seo-gu,
 Daejeon, 35208, Republic of Korea
 Facsimile No. +82-42-481-8578

Authorized officer

Telephone No.

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/KR2019/004927

Patent document cited in search report	Publication date	Patent family member	Publication date
KR 10-2018-0083907 A	23/07/2018	CN 108290770 A EP 3377454 A1 JP 2018-536613 A TW 201728446 A US 10244648 B2 US 2017-0150628 A1 US 2018-0014420 A1 US 2019-0223309 A1 US 9801297 B2 WO 2017-087432 A1	17/07/2018 26/09/2018 13/12/2018 16/08/2017 26/03/2019 25/05/2017 11/01/2018 18/07/2019 24/10/2017 26/05/2017
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Form PCT/ISA/210 (patent family annex) (January 2015)